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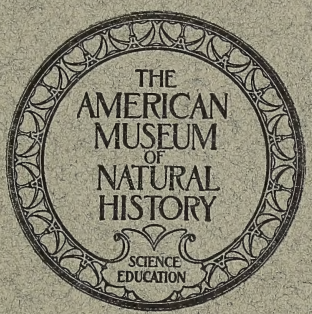
OF

THE AMERICAN MUSEUM OF NATURAL HISTORY

VOLUME XLVI, 1922



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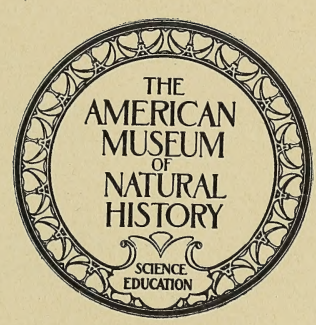

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" 38, line 12 from bottom, for *Kallula* read *Kaloula*.
" 100, line 6 from bottom, for Argyradite read Argyrodite.
" 106, line 18 from bottom, for Sommerville read Somerville.
" 120, line 18 from top, for Breithopite read Breithaupite.
" 120, line 8 from bottom, for Brochanthite read Brochantite.
" 138, line 3 from top, for Gereas read Geraes.
" 163, line 6 from bottom, for Freidlerite read Fiedlerite.
" 193, line 18 from bottom, for 1.39.1 read 13.9.1.
" 195, line 6 from bottom, for Mauzellite read Mauzeliite.
" 230, line 16 from bottom, for Realger read Realgar.
" 230, line 14 from bottom, for Alchar read Allchar.
" 232, line 4 from top, for Reibeckite read Riebeckite.
" 238, line 1 from top, for Seligmanite read Seligmannite.
" 241, line 11 from bottom, for Sousmansite read Soumansite.
" 249, line 15 from bottom, for Sulphoborate read Sulphoborite.
" 265, line 14 from top, for $\frac{1}{3}^{7}$ read $\frac{1}{2}^{7}$ and for 3 read 2.
" 265, line 19 from top, for 17 read 27 throughout line.
" 265, line 15 from bottom, for $\overline{91}$ read $\overline{19}$.
" 439, line 18 from bottom, delete the second with.
" 448, line 14 from top, for disk on read disk than on.
" 449, line 7 from bottom, for *Macrolapmis* read *Macrolampis*.
" 456, line 10 from bottom, for *Claucus* read *Glaucus*.
" 467, line 1 from top, for *sauvis* read *suavis*.
" 470, line 20 from bottom, for in *nefarius* read is *nefarius*.
" 542, line 14 from top, for *Bratrachiderpeton* read *Batrachiderpeton*.
" 630, line 17 from top, for *Phyolldactylus* read *Phyllodactylus*.

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Article I.—THE PHYLOGENY OF THE SALIENTIA

I. THE OSTEOLOGY AND THE THIGH MUSCULATURE; THEIR BEARING ON CLASSIFICATION AND PHYLOGENY

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PLATES I TO XXIII

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INTRODUCTION

Although the frog is perhaps as well known anatomically as any vertebrate except man and is one of the most familiar animals of both anatomical and physiological laboratories, nevertheless, our knowledge of the structure of frogs other than the genus *Rana* is extremely limited and based upon the study of very few types. This lack of information concerning the structure of any but the most familiar forms is chiefly responsible for the artificial and largely arbitrary classification at present in use. In recent years a few of the specialized forms have been studied, chiefly by Beddard, but these accounts are neither sufficiently detailed nor include enough forms to be of value to us in a phylogenetic study. The great need has been a detailed study of any structure carried through a large series of genera, in order that it may be definitely stated whether or not the various modifications of that structure may be utilized in bolstering up our present weak classification, or perhaps can form the basis of a more solid one. In the present paper, I have first tried to place our present classification on a firmer basis, and then have examined in detail the modifications of a single complex, the thigh musculatures through a great many genera with a view to determining how far this evidence supports the revised classification. Much more work remaine to be done in studying other structures throughout a sufficiently large number of genera. It is only then that this revised classification can be fully accepted. In the meantime, I believe it will remain a suggestive scheme, and it is the only one that seems to be supported by all the known facts.

In studying the specialization which the thigh musculature of the frogs has undergone, it was found advisable to attempt to homologize the thigh muscles with those of the salamander. Attempts by former workers could not be accepted for various reasons. I have had the advantage of examining numerous genera of both frogs and salamanders. Of equal importance is the fact that I have been able by means of the acetic-osmic method to study the innervation of the thigh musculature in more detail than have these former writers. The thigh musculature of the most primitive frogs was found to be not very different from that of the more generalized salamanders. Starting with this primitive type, it was possible to trace out several distinct but often parallel lines of specialization.

Lastly, the different point of view expressed in this paper regarding the classification of the Salientia has called for a reconsideration of

the migrations and adaptations of the frogs and toads. Amphibians, because of their dependence on many factors in the environment, have been recognized as excellent material for zoögeographic studies. It is obvious that no zoögeographical discussion can have much importance unless based on a consideration of natural groups. The present paper is primarily an attempt to determine what are the natural groups and, while it is realized that these conclusions may be modified as more structures are fully examined, nevertheless, it is believed that we have now sufficient data assembled to warrant the establishing of a sounder concept of the phylogeny of the Salientia.

In the course of the work I have supplemented my study of the extensive material in The American Museum of Natural History by an examination of many unique or rare forms in the Museum of Comparative Zoölogy, Cambridge, Mass. My thanks are due to Dr. T. Barbour for this privilege. I am also indebted to Dr. A. G. Ruthven of the University of Michigan for the loan or exchange of several interesting species. I am especially obliged to him for the opportunity of dissecting a unique specimen of the remarkable frog *Amphignathodon*. Dr. L. Stejneger of the U. S. National Museum has loaned me several interesting neotropical forms. Mr. H. A. Fowler of the Philadelphia Academy of Natural Sciences has placed the collections of the Academy at my disposal. I am indebted to Dr. E. D. Merril of the Bureau of Science, Manila, and to Mr. E. H. Taylor for a paratype of *Hazelia spinosa*. Throughout the work I have had the kindly aid and advice of Dr. W. K. Gregory.

INADEQUACY OF TAXONOMIC CHARACTERS AT PRESENT IN USE

Present Status of Classification

Our present classification of the Salientia dates from the appearance of Boulenger's 'Catalogue' in 1882, although this system was but a modification of that proposed by Cope in 1864 and 1865. The history of the classification has been outlined by Hoffmann (1878) and Gadow (1901) and need not be entered into here. Since the appearance of Boulenger's 'Catalogue' much evidence has been brought forward from time to time tending to show that our present classification of the frogs and toads is largely artificial. This evidence has not been brought forward in any one paper, although Gadow (1901) and Boulenger (1910) in their recent general books have made certain constructive changes in the system.

It is very regrettable that so few characters are utilized in our system of classification. Not only are these characters few in number but some of them are certainly not of primary importance. It is, perhaps, not surprising that so much destructive evidence has been brought forth in recent years against our present classification. Of constructive contributions, there have been but few. The chief objection to all of these is that the investigators have considered far too few forms. Even such an extensive work as that of Beddard (1907*a*) on the Pelobatidæ must be carried further through other genera before it can be accepted.

But a small proportion of the few characters given by Beddard (1907*a*, p. 904) as defining the Pelobatidæ are actually distinctive of the family. I find that the œsophageal muscle is wanting in both *Scaphiopus holbrookii* and *Pelodytes punctatus*. Beddard was apparently not aware of either the earlier work of Perrin (1892) or that of Nussbaum (1898); otherwise he would not have stated that the absence of a deep-seated semitendinosus was peculiar to the Pelobatidæ. Many leptodactylids (for example *Leptodactylus pentadactylus*) possess a special slip of the rectus abdominis attached to the posterior border of the coracoid. In *Rhinophrynus dorsalis*, this slip is enormously developed. I find a pectoralis, portio epicoracoidea, in *Megalophrys montana* as well as in all other pelobatids which I have examined. On further investigation some of the structures described by Beddard may be found to be characteristic of the family. This is especially true of the hyoid apparatus and of the urinogenital system.

From what will appear below under the discussion of the pectoral girdle and that of the thigh muscles, it will not seem so remarkable as

Beddard (1908*a*, p. 684) would have us believe "that *Rhinoderma* not only shows no likeness to its ally *Breviceps*, but is even more simple than *Rana*."

The anatomy of at least one of the primitive brevicipitids should be described in detail before one can judge how many, if any, of the specialized features of *Breviceps* and *Hemisus* as described by Beddard are really of value in tracing out a phylogenetic scheme. Unfortunately, the work of Beddard cannot be accepted without verification. For instance, the coraco-radialis is not absent in *Breviceps* as stated by Beddard (1908, p. 40) but is present as a very well-developed muscle.

The recent work of Anthony and Vallois (1914) on the myology and osteology of the shoulder region includes too few forms and is not sufficiently detailed for us to draw conclusions of value to us in determining the inter-relations of the Salientia. Characters which they find diagnostic of genera cannot be utilized as distinctive of families. Thus, I find the two muscles which they call the scapulohumeralis profundus anterior and the subscapularis present not only in *Alytes* but in *Bufo marinus*, *Hyla maxima*, *Atelopus ignescens*, *Pternohyla fodiens*, and in all leptodactylids examined, including the specialized *Batrachophrynus microphthalmus* and *Ceratophrys americana*. These authors indicate both muscles as present in such a specialized brevicipitid as *Kallula pulchra*. The presence or absence of these muscles cannot be used in defining families.

Further, the muscle called supracoracoideus profundus by Anthony and Vallois (*loc. cit.*) seems to be altogether too variable to be utilized in distinguishing the primary groups of Salientia. Still, it is obvious from the work of Anthony and Vallois that the discoglossids have the most primitive pectoral musculature and that the pipids and pelobatids possess a complex but little advanced over the conditions found in the discoglossids, while the representatives of all the other families show more specialized conditions. These conclusions support the conclusions reached below. Still, it must be emphasized that all the work which has been done until now on the pectoral musculature of the Salientia is too incomplete for utilization at this time in a classification.

It is unfortunate that none of this myological work can be utilized at the present moment. We are thus forced to return to the osteological characters which are both few and often untrustworthy. But, as they have been the primary structures about which our ideas of salientian phylogeny have until this time been woven, it is essential that we examine them carefully before rejecting them or continuing to accept them.

Dentition

The presence or absence of teeth have, since the appearance of Duméril and Bibron's 'Erpétologie Générale' in 1841, been considered of primary importance in defining the larger groups of Salientia. In all classifications proposed since that time the families of frogs and toads have been in part distinguished by this presence or absence character. That such a character may not always be of primary importance was noticed long ago by Cope (1867*a*, p. 189). Although Boulenger considered it such in his catalogue (1882), he soon after (1888) called attention to its secondary importance. Gadow (1901) considered the character as worthy of subfamily distinction. This, however, does not seem to me to be any advance. A number of toothless genera have been known since the early investigations of Cope to be more closely related to toothed than to any other toothless genera. The mere relegating of the toothless genera to separate categories, whether these be called families or subfamilies, does not express the genetic relationship. The discovery of *Ophryophyrne* (Boulenger, 1903, p. 187) further confirmed the growing opinion that at least some of the toothless families were heterogeneous assemblages composed of genera derived from totally different stocks simply by the loss of teeth.

It had long been noticed that the so-called teeth in the lower jaw of some forms were not true teeth. Brocchi (1877) had made it clear that in *Hemiphractus* these mandibular teeth were nothing but saw-tooth-like prolongations of the bones composing the lower jaw. Still, these mandibular protuberances were commonly considered the equivalent of teeth in the classifications and, further, were often called teeth. As late as 1917, Arldt speaks (p. 126) of them as teeth and theorizes that the forms possessing them must be more primitive than their relatives having teeth only in the upper jaw, presumably because the ancestral Salientia were supposed to have teeth in both jaws. It was not until Boulenger pointed out the close affinity of *Dimorphognathus* to *Arthroleptis*, the former being merely an *Arthroleptis* which develops "teeth" on the lower jaw in the case of the male, that it became well recognized that families or subfamilies founded on the presence of "teeth" in both jaws were just as artificial groupings as those founded on the total absence of teeth.

The old system of classification, although obviously not expressive of genetic relationship, was apparently without a better substitute when Boulenger (1910) wrote his general work, 'Les Batraciens.' Boulenger

did, however, make a distinct improvement in the system by eliminating the families (or subfamilies) Dendrobatidæ, Ceratobatrachidæ, and Genyophrynidæ, and by referring the genera of which they were composed to the families from which these genera were directly derived either by a loss of teeth or by the development of protuberances on the lower jaw. This system apparently was not accepted by all. Ruthven (1915) described *Geobatrachus*, a new genus, which he referred to the Dendrobatidæ. This genus is a very interesting one, and I shall have occasion to discuss it in more detail below. It is sufficient to say now that Ruthven was mistaken in regard to its lacking the maxillary teeth. They are present in three specimens which I have examined.

I have recently found good reason to reject the Dendrobatidæ. In a study of the osteology, chiefly the pectoral girdle of a great many African ranids, it has been possible to trace out various lines of specialization. I found that *Cardioglossa leucomystax* agrees in regard to its pectoral girdle with *Arthroleptis wahlbergii*, while *Dimorphognathus africanus* is practically identical in a great many characters with *A. batesii*. There is much evidence that *Cardioglossa* has been derived directly from the *A. wahlbergii* = *A. variabilis* stock by a loss of teeth and *Dimorphognathus* from the *A. batesii* stock by the development of protuberances on the mandible. Further, I find that *Mantella ebenaui* agrees with *Arthroleptis* in possessing a widely forked omosternum, in striking contrast to *Dendrobates*. The absence of paired disks on the digital expansions, as well as certain other features, would lead one to infer at once that *Mantella* is in no way related to *Dendrobates*, but has been derived from *Arthroleptis* simply by the loss of teeth.

Arthroleptis is apparently an unstable genus in regard to its dentition. That is, a loss of teeth has taken place more than once within the group. This opinion is confirmed by the very recent discovery of *Schoutedenella*, which seems to have developed from some other species of *Artholeptis* than did *Cardioglossa*. The characters which Witte (1921, p. 18) employs to distinguish *Schoutedenella* from *Cardioglossa* are hardly generic but are sufficient to show that *Schoutedenella* has arisen neither from *Cardioglossa* nor from exactly the same stock as that genus, since *Cardioglossa* has arisen from one species of *Arthroleptis*, and *Schoutedenella* from another. In other words, we can hardly attribute generic importance to the loss of teeth for, when the data are complete as in the case of *Arthroleptis* and its derivatives, we see various species of a single genus losing the maxillary teeth independently of one another, just as various species of a group might independently lose a green coloration or a sharp snout.

Other toothed families besides the Ranidæ must be made to include toothless forms. Boulenger (1888, p. 188) has regarded *Pseudophryne* as a toothless *Crinia*. *Eupemphix* has been definitely called a leptodactylid without teeth (Méhelÿ, 1904, p. 217). Boulenger (1919, p. 470) regards *Scutiger*, *Ophryophryne*, and *Aelurophryne* as toothless pelobatids. The recently discovered *Pseudhymenochirus* gives us further evidence of the loss of teeth within the Pipidæ. I have shown elsewhere (Barbour and Noble, 1920, p. 408) that the family Dendrophryniscidæ should be eliminated from the system for the reason that it is composed of two toothless genera which have been derived from totally different stocks simply by the loss of teeth. In the case of one toothless genus, it has been possible to determine not only the toothed genus from which it was derived but also the exact species.

If the families of Salientia are to embrace only natural assemblages, it is obvious that both the Hemiphractidæ and Amphignathodontidæ should be eliminated. The obvious close relationship of *Dimorphognathus* to *Arthroleptis* and of *Ceratobatrachus* to the Ranidæ forced Boulenger to delete the Ceratobatrachidæ. He recognized, too, that *Genyophryne* was but a brevicipitid which had developed pseudo-teeth on the lower jaw, just as many genera of frogs develop bony growths on other parts of the body, chiefly on the top of the skull and along the back. It is important to emphasize this comparison for, in all cases except two, these pseudo-teeth are essentially the same and may be considered excess bony growths. They are formed by the extended and serrated edges of the angular and dentary. The part played by each of these two elements in the formation of the edge varies with the species. This is readily seen in figures (Plate I) of *Dimorphognathus*, *Ceratobatrachus*, and *Cerathyla*.

No vertebrate, fossil or recent, bears true teeth on the angular. The lower jaw of all frogs is formed chiefly by the angular. I, therefore, doubted very much if true teeth were found on the lower jaw of any frog. Thanks to the kindness of Dr. A. G. Ruthven, I have been permitted to dissect out the jaw of the only specimen of *Amphignathodon* in this country. The conditions found in this remarkable frog are shown in Plate I, figs. 5, 6. As Boulenger stated in 1882, true teeth are present in this genus. I find that they agree with the maxillary teeth even to the minute detail of pulp cavity, ring-furrow, dentine and enamel cap. Further, in this genus, the dentary is extensive and these true teeth lie on its medial face (Plate I, fig. 5). The angular overlaps the dentary and covers the bases of all the posterior teeth, which are inserted only upon the dentary. The presence of these true teeth is even more re-

markable because there can be no doubt that *Amphignathodon* is simply a specialized *Gastrotheca*. These marsupial frogs stand among the most specialized hylids, while hylids, as will be pointed out below, are but specialized leptodactylids. Our knowledge of the internal structure of *Amphignathodon* is small, but sufficient, I believe, to place it among the outermost twigs of leptodactylid specialization. How then did *Amphignathodon* come by its mandibular teeth? Is this a case of reversion? We know that not only the immediate ancestors of *Amphignathodon* but even the most primitive frogs, recent and fossil, lacked mandibular teeth. So far as our classification is concerned, *Amphignathodon*, although unique, may be definitely assigned to a position and therefore need not be considered the sole member of a monotypic family.

The only other frog besides *Amphignathodon* having on the lower jaw tooth-like protuberances which are not of the serrate-edge category is *Grypiscus*. Boulenger (1882) referred this genus to the Amphignathodontidæ. I have recently examined the type and unique specimen (Mus. Comp. Zool., 1497) and find that it has no relation to *Amphignathodon*. Cope (1867) described the specimen as having caducous pleurodont teeth. At the present time the specimen possesses no mandibular teeth at all, and it cannot be stated whether or not there were true teeth such as those of *Amphignathodon*. Still, in the specimen, the dentary of each side is very extensive and extends well above the angular, forming a blade. The pars mentalis of each side is bony, pointed, and inflected backward, forming two spines as in certain species of *Ceratophrys*. *Grypiscus* seems to be closely related to *Cycloramphus*. It possesses straight, not claw-shaped, phalanges. The sacral diapophyses are scarcely dilated (the distal part about a fifth wider than the proximal part). A well-developed omosternum is present. It has vomerine teeth behind the choanæ. In brief, there can be no doubt that *Grypiscus* has evolved from a leptodactylid stock, if not directly from *Cycloramphus*, and has nothing to do with *Amphignathodon*.

The exact structure of the maxillary teeth of *Amphodus* is not known. From Boulenger's (1917) recent description, it seems to be a specialized *Hyla* or *Eleutherodactylus*. The fact that its sacral diapophyses are cylindrical would seem to show its relation to the latter genus. But many small Hylas have practically cylindrical diapophyses. *Hemiphractus* is certainly neither a *Hyla* nor an *Eleutherodactylus*. I (1917, p. 802) have given some reason to believe that *Cerathyla* is closely allied to the leptodactylids, although to just which genus it is difficult to state. In brief, there is at present no evidence that any of the genera having

teeth or pseudo-teeth on the mandible may be grouped into natural categories. They all have arisen independently of one another from less specialized stocks. In the case of many of the genera, we may place our finger on the exact genus, and in one case species, from which the specialized forms have evolved. A system to be natural should recognize the diverse origin of these specialized genera and should not group them together. For this reason, I would not only follow Boulenger in eliminating from our classification the Ceratobatrachidæ and Genyophrynidæ, but I would also delete the Hemiphractidæ and Amphignathodontidæ.

Sacral Vertebra

The form of the sacral diapophyses has been generally conceded to be of considerable importance in defining the primary groups, but I have convinced myself that the exact form of this structure is not diagnostic of the real affinities of many forms. Thus, *Hemisus*, although a brevicipitid, has its sacral diapophyses as nearly cylindrical as the majority of leptodactylids. There is one leptodactylid, *Centrolene*, that has its sacral diapophyses more dilated than many hylids. It is well known that several of the Australian leptodactylids have the sacral diapophyses somewhat dilated, certainly more dilated than the hylids *Gastrotheca* and *Pseudacris*.

The problem of the value of the form of these structures in classification has recently been the subject of considerable discussion. Fry (1915, p. 75) has shown that the pelobatid *Lechriodus* is so nearly identical to the leptodactylid *Phanerotis* "that it is difficult to find even specific characters with which to distinguish them." *Lechriodus* is retained in the Pelobatidæ because it possesses sacral diapophyses which are a trifle more dilated than in *Phanerotis* or the closely related leptodactylids *Limnodynastes* and *Ranaster*. If Fry's sketch (*loc. cit.*, fig. 2*c*) is a correct representation of the sacral vertebra of *Lechriodus*, that genus is very probably not a pelobatid at all but a leptodactylid. Two articular surfaces for the coccyx are indicated, a condition characteristic of the leptodactylids but not the pelobatids (see below). An examination of the muscular anatomy of *Lechriodus* would do much to confirm the opinion that *Lechriodus* is a leptodactylid with sacral diapophyses as much expanded as the typical pelobatids.

Hewitt (1919), in describing his *Anhydrophryne*, experienced considerable difficulty in assigning it to a place in the system where it would be near its closest relatives and at the same time not stand as a glaring exception to the characteristics defining its family. He based his

conclusions on its affinities chiefly from a study of its pectoral girdle, but its distribution also showed that it was probably related to *Phrynomantis* and *Cacosternum*. Hewitt concluded with a good deal of justification that *Anhydrophryne* was a brevicipitid with teeth in the upper jaw as in the "dyscophids" and with sacral diapophyses as nearly cylindrical as in the ranids. If Hewitt's conclusions as to the affinities of *Anhydrophryne* are correct, it is apparent that the dilated sacral diapophyses are not invariably characteristic of the Brevicipitidæ.

I (1917, p. 806) have recently shown that *Hyla fuhrmanni* should be referred to *Hyloscirtus*, a leptodactylid genus, chiefly because of its cylindrical sacral diapophyses. It may still be argued by some that *Hyloscirtus* is a *Hyla* with cylindrical diapophyses. Very small species of *Hyla* often possess nearly cylindrical diapophyses but such conditions are not known in any large species of that genus. It seemed, therefore, justifiable when characters of the vomerine teeth, etc. were also considered to refer *Hyla fuhrmanni* to the leptodactylids. In brief, each case must be considered on its own merits; we cannot arbitrarily state that the form of the sacral diapophyses is diagnostic in all families.

Vertebral Column

By far the most important contribution toward a natural grouping of the frogs and toads made in recent years has resulted from the careful studies of Nicholls (1916) on the vertebral column. But in the five years since the appearance of this paper little comment or criticism has been aroused. Nicholls, with the osteological wealth of the British Museum at his disposal, has been able to demonstrate clearly that the classical researches of Gadow were not wholly correct. He has shown that four types of vertebral columns are found in the Salientia and has attempted to divide the Phaneroglossa into four "tribes" on the basis of this structure. He (p. 86) defines these four tribes as follows.

I. Opisthocœla. Sacral vertebra biconvex, free from coccyx; pre-sacral vertebræ eight, opisthocœlous; with ribs.

Includes but one family, the Discoglossidæ.

II. Anomocœla. Sacral vertebra ankylosed to coccyx or articulating herewith by a single condyle; vertebræ procœlous (rarely opisthocœlous); without ribs.

Includes a single family, the Pelobatidæ.

III. Procœla. Sacral vertebra free, articulating with the coccyx by a double condyle; vertebræ uniformly procœlous.

Includes the Bufonidæ, Hylidæ, and Cystignathidæ.

IV. Diplasiocœla (=Firmisternia). Sacral vertebra biconvex, eighth vertebra biconcave; the first seven vertebræ procœlous.

Includes the Ranidæ and Engystomatidæ.

It is interesting to note that these four divisions group the frogs and toads into natural categories. It has been shown that certain bufonids and leptodactylids have been derived directly from leptodactylid genera by that often repeated phenomenon—a loss of the maxillary teeth. It has been further demonstrated that the form of the sacral vertebra does not invariably distinguish a brevicipitid from a ranid or a hylid from a leptodactylid. It might, therefore, be desirable to use these four "tribes" as our primary units—our first natural units larger than genera. Within these units we might be able to arrange a number of parallel series illustrating the loss of teeth or the dilation of the sacral diapophyses. This, I believe, would give us for the first time a natural grouping of the frogs and toads.

Unfortunately, the solution of our problem is not so simple. The units defined by Nicholls are not nearly so circumscribed as he was led to believe by an examination of the largest collection of batrachian skeletons in existence. The collection of frog and toad skeletons in The American Museum of Natural History numbers only one hundred and thirteen specimens but, as the greater part of this collection was prepared by myself with special reference to forms which would yield exceptions to the principles laid down by Nicholls, it clearly demonstrates that the principles of Nicholls cannot be accepted in an unmodified form. In the preparation of these skeletons, I have used a modification of the Schultze corrosive technique which, when combined with a staining process, gives the best results. Since the resulting specimens were preserved in glycerin, the vertebral columns could be readily handled under the binocular and, with the aid of the dissecting needles, the vertebræ manipulated until the exact form of each centrum was determined. Nicholls was not so fortunate in the determination of all of his material and was forced to leave an element of doubt in a small percentage of his results.

The following sixty-five skeletons in The American Museum of Natural History agree entirely with the conclusions reached by Nicholls. The number of specimens and the locality, when important, are included in brackets.

Opisthocœlous

Pipa pipa (2); *Xenopus tropicalis, X. mulleri; Bombina maxima;* and *Ascaphus truei.*

Procœlous

Bufo marinus (3), *B. fowleri, B. superciliaris* (14); *Cerathyla johnsoni; Eleutherodactylus martinicensis* (3), *E. montanus* (2); *Gastrotheca bolivianum; Hyla andersonii, H. dominicensis, H. rubra, H. septentrionalis, H. versicolor; Leptodactylus lineatus; Pseudacris septentrionalis; Telmatobius culeus.*

DIPLASIOCŒLOUS

Arthroleptis feæ; Cacosternum boettgeri; Chiromantis rufescens; Dimorphognathus africanus; Gastrophryne carolinensis (3); *Hemisus marmoratum; Hyperolius concolor, H. nasutus; Kassina senegalensis; Hypopachus variolosus* (2); *Leptopelis aubryi; Megalixalus fornasinii, M. leptosomus; Otophryne robusta; Phrynobatrachus natalensis; Rana aesopus, R. albolabris, R. catesbeiana, R. occipitalis, R. septentrionalis, R. sylvatica, R. temporaria, R. virgatipes.*

The following fifty specimens are at variance with the conclusions reached by Nicholls. Nicholls mentioned that *Rhombophryne testudo, Atelopus ignescens, A. oxyrhynchus,* and four species of *Polypedates* did not agree with his conclusions but he chose (p. 91) to consider these as "persisting forms which appear to connect the several groups," and not as serious obstacles to the acceptance of his system. A few of the specimens indicated below are undoubtedly instances of abnormality, but the majority are "persisting forms"—much too numerous for us to disregard in our classification. All of these specimens are firmisternal and should therefore be diplasiocœlous if they were to agree with Nicholls' conclusions.

Arthroleptis pœcilonotus and *A. variabilis* (4), uniformly procœlous. Nicholls (p. 82) states that the specimen of *A. variabilis* examined by him was diplasiocœlous.

Atelopus elegans, A. ignescens, and *A. varius* (2), all procœlous and with vertebræ I+II fused (as in *Pipa*). Three additional skeletons of *A. varius* show the following conditions: A. M. N. H. No. 11278, vertebræ I+II fused and the potential VIII+IX (sacral) fused (Plate III, fig. 2); A. M. N. H. No. 11279, only seven precoccygeal vertebræ; I+II fused, potential VIII forming the left sacral diapophyses, and IX the right, but vertebræ IX part of coccyx (Plate III, fig. 3); A. M. N. H. No. 11280, vertebræ I+II fused; potential VIII+IX fused to form a sacral vertebra of practically the same form as the normal sacral vertebra (Plate III, fig. 1).

Brachycephalus ephippium, procœlous, IV+V fused.

Cardioglossa elegans, procœlous, VIII+IX (sacral) fused.

Dendrobates parvulus, D. trivittatus and *D. tinctorius* (1 Costa Rica and 1 British Guiana), uniformly procœlous. *D. typographus* (4 Nicaragua, 2 Costa Rica, and 2 probably from Costa Rica) and "*D. tinctorius*" (1 Colombia and 2 Ecuador), vertebræ II+III and VIII+IX fused. One *D. typographus* (?) from Costa Rica has I+II+III and VIII+IX fused (and thus as in *Hymenochirus,* has only five presacral vertebræ). One immature *D. typographus* (A. M. N. H. No. 8217), only 14 mm. in length, has vertebræ VIII+IX fused and II+III approximated (Plate II, fig. 3). Another immature specimen (A. M. N. H. No. 3814) doubtfully referred to *D. typographus* does not show these fusions. From the above series of *Dendrobates,* it may be concluded that the normal adult condition of *D. typographus* and the Colombia-Ecuador races of that assemblage known as *D. tinctorius* is the fusion of the vertebræ II+III and VIII+IX.

Geobatrachus walkeri, uniformly procœlous.

Hyloxalus collaris, uniformly procœlous.

Phyllobates boulengeri, P. infraguttatus (7), and *P. trinitatus,* uniformly procœlous.

Phrynobatrachus dendrobates, VIII opisthocœlous, VII biconcave.

Rana cæruleopunctata, R. christyi, and *R. pipiens* (?), VIII+IX (sacral) fused.

Rhinoderma darwinii, uniformly procœlous.

Sminthillus limbatus, S. peruvianus, uniformly procœlous.

If the above list is added to that of Nicholls, the following fundamental conclusions may be reached.

(1) The uniformly procœlous condition is typical, not only of the Bufonidæ, Hylidæ and Leptodactylidæ, but also of all the firmisternal neotropical genera examined except *Hypopachus* and its close allies, *Gastrophryne, Otophryne,* etc. These typically procœlous genera include *Sminthillus, Geobatrachus, Brachycephalus, Phyllobates, Hyloxalus, Dendrobates, Atelopus,* and *Rhinoderma.*

(2) *Atelopus* is characterized not only by a procœlous condition but also by a fusion of I+II vertebræ.

(3) *Dendrobates typographus* and a race of frogs at present referred to *D. tinctorius* have normally the II+III and the VIII+IX vertebræ fused.

Only the first of these three conclusions is of interest to us from a taxonomic standpoint. The second and third is of interest from a more general phylogenetic point of view. As we shall point out below, it is very probable that the typically procœlous firmisternal forms are not at all related to the diplasiocœlous firmisternal genera. In other words, the neotropical firmisternal genera, except *Hypopachus, Gastrophryne,* and their close allies, are not at all related to the palæotropical or, in fact, to any other firmisternal forms.

The third statement calls for further explanation in regard to my uncertainty in referring a name to the race mentioned. No name can at the present time be given to the Ecuadorian-Colombian specimens of *D. tinctorius* because of the great confusion in the synonymy of that species. I have shown elsewhere (Noble, 1918, p. 320) that the Colombian specimens are apparently most like the typical *D. tinctorius* as regards certain characters. Nevertheless, it seems extremely probable that they are closely allied to *D. typographus* and only distantly related to the *D. tinctorius* of Guiana. This opinion is supported by the fact that the omosternum of the adult *D. typographus* and the *D. tinctorius* of northwestern South America remains cartilaginous and often rudimentary, while in one specimen of *D. tinctorius* from Guiana and another from Costa Rica it is bony, similar to that of *D. trivittatus* and *D. parvulus.* In brief, it seems that *D. typographus* might well be considered

the type of a new genus characterized by a vertebral column of only six presacral segments and a rudimentary omosternum. Until the internal structure of many more specimens of *D. tinctorius* can be examined, especially specimens from Guiana, the status of such a genus would be on a very weak footing.

Skull

It is well known that Cope was misled in laying considerable stress on small differences in skull form in his early classical studies on the Salientia. It is now generally conceded that the degree of ossification of the skull and the exact extent of the derm bones is not even of generic importance, although recent attempts have been made to erect subgenera on a basis of skull differences. Future detailed work may show that some of the differences are sufficiently constant to be used in defining the families. But at the present time far too few skulls have been examined to determine what these differences are.

The boldest attempt in recent times to depart from the view that the skull of the Salientia is a plastic structure of little importance in classification was made by Méhelÿ (1901) after a study of the Brevicipitidæ of New Guinea. Méhelÿ proposed two new subfamilies, Symphygnathinæ and Eleutherognathinæ, because of differences which he found in the symphysis of the maxillæ of the various genera he studied. This contribution to the classification has not been considered seriously by later workers. Van Kampen (1919, p. 53) has very recently referred Méhelÿ's genera *Gnathophryne* and *Metopostira*, representatives of Symphygnathinæ and Eleutherognathinæ respectively, to a single genus *Hylophorbus*. In other words, Van Kampen would lay primary importance upon the girdle, not skull form, in defining genera.

Pectoral Girdle

Cope (1864 and 1865) was the first to seize upon the importance of the structure of the shoulder girdle in defining the primary groups of Salientia. His system was not accepted at first and later various other systems were proposed. Although Cope (1867*a* and 1875) later modified his system somewhat, laying undue emphasis on the peculiar form of the shoulder girdle of *Hemisus*, it is now generally recognized that he did not improve his original scheme. An outline of the history of the classification has been given by Hoffmann (1878) and Gadow (1901). The more recent account is by no means complete. It omits, for instance, the interesting schemes proposed by Lataste (1879) and by Blanchard

(1885). Boulenger's (1886) and Lataste's (1888) criticisms of Blanchard's scheme are also of importance. Lataste's classification based on the position of the spiracle is now known to be of little value. Rao (1919) has shown that certain brevicipitid tadpoles possess a median spiracle similar to that of the discoglossids. Boulenger (1882) accepted Cope's scheme in a modified form. He divided the Phaneroglossa into two series, the first possessing a shoulder girdle with two halves fused in the midline, and the second with the two halves free and broadly overlapping. Since that time, no conclusive evidence has been brought forward to disprove that the first of these two groups, the Firmisternia, did not embrace a natural group of genera much more related to each other than to any genus of the second series, the Arcifera. It has been pointed out several times that the shoulder girdle of the Firmisternia in its ontogeny passes through an arciferous stage, and it was assumed that Firmisternia were, therefore, higher, more advanced forms than the Arcifera. It would seem *a priori* that this difference between the Firmisternia and Arcifera was structurally a very slight one, and the change from one type to the other might have taken place more than once phylogenetically. Mivart (1869*a*) would not accept Cope's system for he did not believe so much emphasis should be placed on the condition of the pectoral girdle. He adds (*loc. cit.*, p. 281, footnote): "I am fortified in this, I rejoice to say, by the valuable opinion of one of the very first of existing osteologists, I mean my esteemed friend, Mr. W. K. Parker, F. R. S."

Nevertheless, Cope's scheme as modified by Boulenger was universally accepted and since that time no one has pointed out a firmisternous genus that was more certainly allied to an arciferous genus than to any of its firmisternous allies. We have found reason to doubt the trustworthiness of characters of dentition, sacral vertebræ, skull, vertebral column and terminal phalanges; in fact, practically all the major characters at present in use, save only those of the pectoral girdle, have been found to be unreliable in at least one instance.

It will now appear that not even the condition of the pectoral girdle is always diagnostic. There is one genus, *Sminthillus*, recently described by Barbour and myself, in which the pectoral girdle, viewed from the ventral surface, seems to be firmisternous as recently figured (Barbour and Noble, 1920, fig. 2; unfortunately this figure was reversed in printing). This is due in part to its fragile nature and in part to the fact that it is covered with an adherent membrane. But when the girdle is viewed dorsally, and the coracoids pressed gently downward, the two coracoid

cartilages readily separate for about half their length. As this separation occurs only in the region of the coracoids, the girdle must be functionally firmisternous. Morphologically, it is exactly intermediate between the arciferous and firmisternous condition.

I (1921) have very recently described a second species of the genus *Sminthillus*. *S. limbatus* is confined to Cuba, while this second species was secured from southern Peru. Both species agree very well externally and internally, except for the pectoral girdle, with some of the smaller species of *Syrrhophus*. The latter genus is a polyphyletic group of species of *Eleutherodactylus* which have independently lost the vomerine teeth. (A parallel occurs in *Hylella*, etc.) The difference between the pectoral girdle of *Syrrhophus* or *Eleutherodactylus* and *Sminthillus* (Plate IV) is not great. It is certainly simpler, when all things are considered, to assume that *S. limbatus* in Cuba and *S. peruvianus* in southern Peru have arisen independently from a *Syrrhophus* or *Eleutherodactylus* stock rather than to try to account for the distribution by assuming a former greater range and at present restricted distribution. If we carry the argument further, we might ask whether other species of *Eleutherodactylus* or, better, arciferous genera have not repeated this process of fusing the two halves of the pectoral girdle in the midline and have carried the process a step further than *Sminthillus*. It is very suggestive to compare the pectoral girdles of *Eleutherodactylus*, *Sminthillus*, and *Rhinoderma* (Plate IV). The latter has not only its coracoid cartilages completely fused but the metasternum is not distinct from the sternum, suggesting that the process of fusion did not stop with the coracoid cartilages.

But what right have we to assume that any genus except *Sminthillus* has recently made this change from an arciferal to a firmisternal type? All the neotropical firmisternous genera, except *Gastrophryne*, *Hypopachus*, and their close allies, have typically a procœlous vertebral column. We have seen that certain species of African ranids may occasionally possess a procœlous type of vertebral column and also, according to Nicholls, four species of *Polypedates* having very diverse ranges in the east. But these cases are certainly abnormalities. Sufficient material has been examined to state definitely that the Old World ranids are typically diplasiocœlous. We may state from our own observations that the neotropical ranids, except one group, are procœlous. The Leptodactylidæ, Hylidæ, and Bufonidæ, a very natural group of families, are also procœlous. The two former families of frogs are the dominant Salientia of the neotropics. Only a scattering of firmisternal genera occur. Did not these procœlous firmisternous genera arise as *Sminthillus*

from the leptodactylids? *Hypopachus* and its allies may well, as we shall discuss below, have arisen from ranid stock and have reached South America at some early time. It does not seem likely that they have come in recently with *Rana*. Hence, from the evidence of the vertebral column and the pectoral girdle, the majority of South American firmisternous genera may not have arisen in very ancient times. Further, they have evolved from a stock very different from that of the Old World ranids. That this is probably the correct interpretation of the above facts will appear from the evidence derived from a study of the muscles of the posterior limb.

Discussion and Summary

It is obvious from the above brief criticism that the few pegs on which our classification has hung for so many years are giving way, if not already worthless. We can no longer be sure that the toothless forms are related or that those frogs with tooth-like protuberances on the lower jaw are anything but highly specialized forms which have developed these growths quite independently of any other form. It also appears that the shape of the sacral vertebræ is by no means always diagnostic of a family or even a group of related genera (*Cacosternum*, etc.) We have shown that certain neotropical genera possess a shoulder girdle exactly intermediate between the arciferous and firmisternous condition. There never has been sufficient evidence for us to place much faith in any of the numerous skull differences as defining larger groups. Lastly, we have just shown that there are a number of suggestive exceptions to the recent conclusions derived from a study of the vertebral column. At first glance, it would seem useless for us to attempt to reconstruct a classification on the basis of any of the above characters. Still, some of them are certainly indicators of natural relationships, even if not always reliable indicators. Until more structures have been studied in detail and throughout a sufficient series of forms, we must depend on the characters at hand.

Of the characters discussed, only those of dentition seem absolutely worthless and of little use for us to consider further. Boulenger realized this and eliminated the three families Ceratobatrachidæ, Genyophrynidæ, and Dendrobatidæ, based primarily on such structures. We have shown equally good reason to delete the Dendrophryniscidæ, Hemiphractidæ, and Amphignathodontidæ. The relationships of *Phrynomantis* to *Anhydrophryne* and *Cacosternum* suggest that the Brevicipitidæ are but toothless dyscophids. The many extraordinary similarities we find in

both internal and external structure, especially as regards the greatly reduced pectoral girdle in certain genera of both groups, brings one to the conclusions that all Old World brevicipitids, those with diplasiocœlous vertebral columns, have been derived either directly or more often indirectly from the Dyscophidæ, that is, from a stock similar to themselves but possessing maxillary teeth. For that reason, I do not hesitate to merge the brevicipitid and dyscophid genera into a single family and, as the genus *Breviceps* has priority over *Dyscophus*, the name Brevicipitidæ may be used for that family.

There remains to be considered only one family based primarily on the absence of teeth. This is the Bufonidæ. It has been shown that certain bufonids (*Eupemphix* and *Pseudophryne*) are nothing but toothless leptodactylids. Are all bufonids toothless leptodactylids? The distribution of the two families would seem at first to deny this. But, if we admit with Boulenger that *Pseudophryne* is simply a toothless leptodactylid, the problem becomes less difficult. I have shown (in manuscript) that *Pseudophryne* is hardly separable from *Nectophryne*. The latter genus has a wide distribution in the oriental region. May not some of the oriental bufonids have been derived from *Nectophryne* or at least in some such indirect way from true leptodactylids, that is, from bufonid-like creatures still retaining the maxillary teeth? It may, of course, be argued that we cannot place our finger on the leptodactylid genus from which *Bufo* was derived and thus, even if we should relegate a number of bufonids to the leptodactylids and admit that they cannot be distinguished by any family character from *Bufo*; nevertheless, we should not part with the time-honored family Bufonidæ, but should retain it if only for the genus *Bufo*. Conservatism in classification is much to be desired but I cannot see the point of retaining a family when there is not a single character to define it. Moreover, Oeder (1906, p. 538) has shown that the tadpole of *Bufo* possesses a tooth ridge and tooth furrow in the upper jaw. He regards these as rudimentary organs, definite evidence that the immediate ancestors of *Bufo* possessed teeth in the upper jaw. The bufonid and leptodactylid genera exhibit no constant features by which to distinguish them. I am therefore forced to merge them into a single family and, as the name *Bufo* is older than *Leptodactylus*, the name Bufonidæ may be retained for this family.

If, then, we have rid the classification of dentition characters, which of the other characters are the most stable and at the same time divide the Salientia up into what we realize are natural groups? I say "realize" because there is much evidence to be derived from zoögeography and

from a handling of many species. The first kind of evidence is indirect while the second cannot be expressed in definite terms for it comes from an appreciation of many small indefinable characters. A few other characters besides those discussed above have been suggested as a basis of classification. As the value of certain of these has not been disproved, they remain available to us. Perhaps the most important of these characters is the presence or absence of ribs. Féjérvary (1918) has attempted to throw doubt on the importance of this character by claiming that the anterior diapophyses of all frogs are potentially ribs. The fact remains that these diapophyses in most frogs are morphologically not ribs, since at no stage of their ontogeny are they isolated from the vertebræ. In the Pipidæ, the ribs are distinct only in the larva. Upon metamorphosis they ankylose to the vertebræ. This, I (in manuscript) have shown by photographs. Still, these larval ribs are not found in any other family save the Discoglossidæ, in which group they are retained throughout life.

The Pipidæ have been placed in a suborder by themselves by practically all recent workers. The suborder, the Aglossa, has been characterized by the absence of a tongue, vertebræ opisthocœlous, sacral diapophyses dilated, ribs present. The last three characters are shared equally by the Discoglossidæ, while the first does not seem to me to be very fundamental. It is almost certainly an adaptation to aquatic life. *Batrachophrynus* is one of the most aquatic of the Bufonidæ (employing our new terminology), and this genus possesses but the slightest indication of a tongue. Further, it has lost the eustachian tubes, which structures seem to be highly modifiable in the Salientia.

Of all the characters which have been fully investigated, those of the vertebral column seem to me the most important. Then follows a choice of several characters, none free from exceptions. As these characters will be discussed more fully at the end of the paper, we shall simply state them briefly here in order that we may have before us, as we consider the musculature of the thigh, a scheme which, if not entirely satisfactory, is nevertheless the best working basis to be derived from the data available. It will be noted that this scheme is an elaboration of that proposed by Nicholls (1916), together with certain important changes, additions and omissions.

Order.—Salientia

Sub-Order I.—Opisthocœla

Presacral vertebræ opisthocœlous; ribs present at some stage in development.

1.—Pipidæ. Sacral vertebra fused with coccyx; presacral vertebræ seven to five; opisthocœlous with ribs in early stage of development; eyes without movable eyelids (except in *Pseudhymenochirus*); no tongue; pectoral girdle arcifero-firmisternal; coracoid cartilages not overlapping but attached to each other along the medial edge.

2.—Discoglossidæ. Sacral vertebra free, with biconvex centrum; presacral vertebræ not less than eight; opisthocœlous; with ribs in adult; tongue and eyelids present; pectoral girdle arciferal.

Sub-Order II.—Anomocœla

Sacral vertebra procœlous, ankylosed to coccyx or if free with only a single articular condyle for coccyx (except in *Pelodytes*); presacral vertebræ eight, uniformly procœlous (rarely opisthocœlous); without ribs at any stage in development.

3.—Pelobatidæ. Sacral diapophyses dilated; pectoral girdle arciferal.

Sub-Order III.—Procœla.

Sacral vertebra free, procœlous, with double condyle for coccyx; presacral vertebræ eight to five, procœlous; without ribs.

4.—Bufonidæ. Pectoral girdle arciferal; sacral diapophyses cylindrical or dilated; presacral vertebræ eight; terminal phalanges T-shaped or simple (very rarely claw-shaped).

5.—Hylidæ. Characters of Bufonidæ but terminal phalanges claw-shaped, supported by an intercalary cartilage or bone; the sacral diapophyses dilated.

6.—Brachycephalidæ. Pectoral girdle arcifero-firmisternal (Pl. IV, figs. 2, 3) or firmisternal; sacral diapophyses cylindrical or dilated; presacral vertebræ eight to five, but generally less than eight; terminal phalanges never claw-shaped.

Sub-Order IV.—Diplasiocœla

Sacral vertebra biconvex with double condyle for coccyx; eighth vertebra biconcave, preceded by seven procœlous vertebræ; without ribs.

7.—Ranidæ. Sacral diapophyses cylindrical or slightly dilated; pectoral girdle firmisternal.

8.—Brevicipitidæ. Characters of Ranidæ but sacral diapophyses more dilated.

THE THIGH MUSCULATURE AS A BASIS OF CLASSIFICATION

Historical

There are many accounts, most of them not at all complete, of the myology of the more familiar genera. The earlier accounts are meagre, but in some points more accurate than some of the most recent. *Rana* has been the most exhaustively studied. The work of Gaupp (1896–1899) has been considered a standard for the present paper. Although it will be obvious from the following that there is little basis for the mammalian names which Gaupp has retained, since in the great majority of cases the frog muscles are not at all homologous with the mammalian muscles of the same name, nevertheless, these inappropriate names have been used throughout this paper in order to save confusion. Once the homologies suggested in this paper have been generally accepted, it will be time enough either to abolish the mammalian names, utilizing the urodele names instead, or, perhaps better, to apply the mammalian names to truly homologous muscles.

Gaupp's work (1896–1899) is generally considered the classical treatise on *Rana*. It is based chiefly on *R. esculenta*. Gaupp includes references to most of the earlier works but, as these accounts add nothing to Gaupp's descriptions, we shall not consider them here. Only one later paper may be mentioned as an important contribution to the study of the thigh muscles of *Rana*. Nussbaum (1898) has considered the minute differences between the thigh muscles of *R. esculenta* and *R. fusca*, as well as several other forms. His description of the nerves of this region is more detailed than that of Gaupp. Some mention of other species of *Rana* has been made in more recent contributions. The thigh muscles of *R. guppyi* have been figured by Beddard (1907*a*, fig. 234). The differences in musculature between the various species of *Rana* are not sufficiently great to concern us in the present paper.

Various species of the toad *Bufo* have been studied. The first good account considering the myology of the posterior limb available to me is that of Zenker (1825). Altena (1829) considers the muscles of the toad in a more comparative way. The most complete of these earlier papers is that of Dugès (1834). It has been considered the basis of much of the later work. I have not been able to examine the paper by Collan (1847). Unfortunately, the important paper of Klein (1850) is without figures. Stannius (1856) reviews a part of this earlier literature, and Hoffmann (1878) considers the more important papers. The more recent papers have been more broadly comparative and therefore of greater value to

us. De Man (1873, 1874) and Perrin (1892) have furnished the most detailed of these contributions. Gaupp (1896*a*) has recently added some notes on the skin muscles of *Bufo*.

Hyla has been considered together with *Bufo* in most of the accounts. Zenker, Altena, Dugès, Klein, Stannius, and Hoffmann have considered *Hyla* in more or less detail. The comparisons of De Man (1873, 1874) and Perrin (1892) have been the most useful in our present study.

The aberrant *Pipa* has been the subject of considerable study. The thigh muscles have been investigated by Breyer (1811), Mayer (1825), and Klein (1850), and critically reviewed by Hoffmann (1878). It is unfortunate that Beddard (1895) did not consider all of these reports. He has confused badly some of the most essential features in the thigh of *Pipa*. For instance, he claims that the pectineus is absent while the pyriformis is lacking. As a matter of fact, the pectineus is present as a well-developed muscle while the pyriformis is absent. This was recognized long ago by Klein (1850).

Other genera of frogs and toads have not been considered in as much detail as any of the above. Zenker (1820), Altena (1829), Dugès (1834), Hoffmann (1878), Perrin (1892), and Nussbaum (1898) have studied one or more of the discoglossids. If this group had been studied in greater detail, the homologies of the salientian thigh muscles would have been better understood.

A few of the toothed bufonids ("leptodactylids") have been investigated in regard to their thigh muscles. One of the earliest papers is that of Kloetzke (1816) on *Ceratophrys cornuta*. Steffen (1815) considers the skin muscles of a species of *Leptodactylus*. Klein (1850) has studied *L. ocellatus*. Hoffmann (1878) has reviewed the literature and made some comparative notes.

Only the most incidental reference to the thigh muscles of the pelobatids appears in the earlier literature. These references, such as those of Dugès (1834), are of little value in a detailed study. The first good account of the pelobatid thigh musculature is that of Nussbaum (1898). Unfortunately, Beddard (1907, 1907*a*, and 1911) was not familiar with this work when he wrote his papers on the pelobatids.

Other families of frogs and toads have been very superficially studied. The specialized brevicipitids, *Breviceps* and *Hemisus*, have been investigated by Beddard (1908, 1908*b*, and 1911). The brachycephalid *Rhinoderma* has been briefly treated by the same author (1908*a*). The myology of the pipid *Xenopus* has been compared by Beddard (1895*a*) with that of *Pipa*. Unfortunately, some of this later work leaves much to be desired.

The above work may for the most part be classed under one of two categories. The authors have either attempted to homologize the muscles directly with those of mammals, or they have described the muscles as they found them, assigning them mammalian names and making brief comparative note of the conditions found in other genera of Salientia. None of the authors have examined a sufficiently large series of genera to discuss at all fully the specializations found within the Salientia. The specialization of certain muscles, such as the sartorius and the semitendinosus, have been considered chiefly by De Man (1873, 1874), Perrin (1892), and Nussbaum (1898). The first and last of these authors have pointed out some differences in the distal tendons of the thigh in *Rana* and *Bufo*. De Man (1873, 1874) and Perrin (1892) have attempted to homologize the muscles of the frog with that of the salamander, but these authors have not understood the several types of modification which occur again and again in the Salientia. They have not compared the most primitive type of musculature found in the Salientia with the most generalized in the urodeles. The present paper attempts to fulfill both these needs: first, to give an account of the specialization of musculature found within the various families of frogs and toads, and, second, to compare primitive conditions in the frog with those in the salamander.

Musculature Specialization

A detailed description of the slight variations in proportion, origin, and insertion found in the thigh muscles of the various genera of Salientia would be voluminous and quite beyond the scope of the present paper. It has been observed that certain of these differences have a phylogenetic bearing, and they alone are discussed below. Detailed descriptions of the thigh muscles, together with their innervation, have been given by Gaupp (1896–1899) for *Rana* and by Nussbaum (1898) for several other genera. It is only the deviations from these accepted conditions that are emphasized below.

Adductor longus

The homologies of no muscle in the thigh of the frog is more certain than that of the adductor longus and yet none of the many investigators who have considered salientian myology have brought out these relations. The adductor longus is merely a separate slip of the pectineus. In primitive Salientia it remains undifferentiated. The adductor longus is not present as a definitive muscle in the pipids (Plates VIII, IX, and X)

in spite of Beddard's (1895) statement to the contrary. The primitive discoglossids and pelobatids have similarly not developed an adductor longus, while the specialized genera and species have one. *Ascaphus* and *Bombina* are in many ways the most generalized of the discoglossids. *Ascaphus* lacks any indication of an adductor longus. *Bombina* possesses a wide pectineus which, on being tweezed, splits up into two or three masses. Still, I cannot agree with Nussbaum (1898) that the anterior of these masses should be called an adductor longus, for it is bound in the same sheet of connective tissue as is the rest of the pectineus and can be distinguished from it only by careful dissection. *Discoglossus* and *Alytes*, on the other hand, have a very distinct adductor longus. In the pelobatids, it is not present in *Scaphiopus* (Plate XI) but it is well developed in *Pelobates fuscus* (Plate XII, fig. 3) and *Pelodytes punctatus* (Plate XII, fig. 4). The actual morphogenesis of the adductor longus may be seen within the genus *Megalophrys*. In *M. hasseltii* (Plate XII, fig. 1) it is not distinct, while in *M. montana* it has barely split off from the pectineus. *M. major*, *M. nasuta*, and *M. feæ* possess a well-developed adductor longus. The innervation of the adductor longus shows its very close genetic relationship to the pectineus.

Beddard (1895*a*, p. 847) claims that in *Xenopus* the adductor longus is present, while the obturator externus and pectineus form an inseparable mass. The innervation and relative positions of the muscles show that what Beddard described as the adductor longus is the pectineus, while his pectineus-obturator externus is actually the obturator externus alone (Plate X). Beddard (1895, p. 840) describes an adductor longus in *Pipa*. Here, too, he has badly confused the muscles.

All of the higher types of frogs possess an adductor longus. It is universally present in the ranids, brevicipitids, and hylids. Two brachycephalids (*Atelopus* and *Oreophrynella*) and two bufonids (*Nectophryne* and *Mixophyes*) lack the adductor longus. It is impossible to say whether the muscle has secondarily fused with the pectineus, or dropped out entirely. All the other brachycephalids and bufonids which I have examined for this structure possess it as a well-developed muscle.

Pectineus

The pectineus is one of the fundamental muscles of the Salientian thigh. It is present in all the numerous species which I have examined. Beddard (1895, p. 840) claims it is absent in *Pipa*. I have found it present in this genus as a very distinct muscle, although covered by the abdominal muscles attaching to the femur. It has exactly the same relations in *Hymenochirus* (Plate IX, fig. 2).

In *Pipa*, the pectineus attaches to the pubo-ischium on the antero-ventral process, which in this genus is pronounced. In *Bombina maxima*, the pubic cartilage is not calcified and the pectineus attaches to its anterior margin. In *Ascaphus* (Plates VI and VII), the pectineus attaches not only to the anterior face of the calcified pubic cartilage, but also to the prepubis along its median line (Plate VII, fig. 2). It is probable that this prepubis, like the two post-pubic cartilages, is an adaptive structure of recent acquisition. The former occurs also in *Xenopus* and a portion of the pectineus originates from it. The greater part of the pectineus attaches to the pubic cartilage and it would seem that this was the primitive position from which a few muscular fibers have shifted their attachment onto the prepubis. One is tempted to homologize the prepubis with the ypsiloid apparatus of the salamander. This homology is supported by the fact that the prepubis is found in only the more primitive Salientia. Still, it occurs in very few species of Salientia and, further, the puboischiofemoralis internus of the salamander, which, as we shall point out below, is homologous to the pectineus, does not insert on the ypsiloid apparatus. It seems most probable that the prepubis is a recently acquired structure of no phylogenetic significance.

Iliacus internus and externus

These two muscles are undoubtedly closely related and must have formed in the Pro-Salientia a single mass. They are both innervated by branches from a single trunk. It is probable that the twisting of the ilium in the morphogenesis of the salientian pelvis split the mother mass into the two muscles.

The most primitive condition of the iliacus internus and externus is that found in *Ascaphus*. The two muscles are fairly distinct but the iliacus externus is broad, and strap-shaped, inserting on the head of the femur by a wide, non-tendinous head. A comparison of these muscles in *Ascaphus* with the same in *Bombina* will show that the accessory head, so well described by Nussbaum (1898) in the latter genus, has arisen by a splitting of the iliacus externus and has no genetic relation to the iliacus internus, as Nussbaum would have us believe. All the discoglossids except *Ascaphus* exhibit a well-developed accessory head. In *Bombina* and *Alytes* the accessory head, although much longer than the iliacus externus, is not much wider; in *Discoglossus*, the relations are about the same but both muscles are better developed.

All pipids have both iliacus externus and the accessory head well developed. In *Xenopus*, the latter is enormous and broadly overlaps the

former. All pelobatids except *Pelodytes* possess an accessory head, although in most cases it is greatly reduced. In *Scaphiopus*, the accessory head is short, extending not more than one-third the length of the ilium; still, it is a very distinct muscle (Plate XI, fig. 1). The loss of the accessory head in *Pelodytes* may not be very significant in view of its reduction in other genera of the family.

All families of frogs and toads above the discoglossids, pipids, and pelobatids lack the accessory head of the iliacus externus. It is probable that this lack is due to a loss. The series, *Ascaphus*, the other discoglossids, and the pelobatids, illustrates how the iliacus externus, when originally formed, was early associated with an accessory head which in higher forms dwindled and finally disappeared.

Great variation is found in the extent of both iliacus externus and iliacus internus in the numerous species before me. These differences do not seem to be correlated with any natural grouping of the genera and need not be considered here.

Tensor fasciæ latæ

In most Salientia, this muscle appears like a mere slip of the cruralis-glutæus mass attached to the ilium. The reduced condition found in most ranids and bufonids is not the primitive one. The tensor fasciæ latæ is well developed in *Ascaphus* and *Hymenochirus*, less so in other primitive genera. It is most reduced in the ranids, hylids, and bufonids having the longest legs. Its insertion relative to the cruralis and glutæus is variable (Plate VI, fig. 1; Pl. IX, fig. 1). This variation seems to have no phylogenetic significance.

An extraordinary development of the tensor fasciæ latæ occurs in *Atelopus*. Here the muscle is very powerful and attached to the ilium very far forward. The exact position is variable with the species, but in general this attachment is not far from the extreme anterior end of the ilium. The insertion of the tensor fasciæ latæ onto the cruralis-glutæus mass is more distal than in most brachycephalids. The enlargement of the tensor fasciæ latæ in *Atelopus* must be looked upon as a secondary specialization, very probably correlated with the peculiar locomotion characteristic of this group.

Adductor magnus, caput dorsale

The adductor magnus consists primitively of two very distinct muscles which have undoubtedly arisen from two different muscle masses of the Pro-Salientia. The accessory head of the adductor magnus is

nothing but a small slip of the dorsal head which has become secondarily attached to the ventral head of the semitendinosus. The accessory head of the adductor magnus is present in only the most advanced groups of Salientia. That the adductor magnus is actually composed of two distinct muscles is shown by the fact that all the discoglossids, pipids, and pelobatids have these two muscles quite separate, although in some of the discoglossids the distal ends of the two muscles are more or less fused. In all higher families, this distal fusion is more pronounced.

No taxonomic value may be placed on the presence of the accessory head. It is altogether too variable a structure. Bufonids exhibit all stages in the development of the accessory head.

The caput ventrale of the adductor magnus, being in no way genetically related to the caput dorsale, will not be considered until further in the discussion. This will facilitate comparison with the table of homology given below.

Obturator externus

Primitively, this is a very well-developed muscle as shown in *Pipa* (Plate VIII) or *Hymenochirus* (Plate IX). Not all generalized Salientia have such a large obturator externus as occurs in these two genera but in all it is a very distinct muscle lying immediately dorsal to the proximal part of the adductor magnus, caput ventrale. In *Pipa* and *Hymenochirus*, the abdominal muscles attach to the femur between the obturator externus and pectineus; in all other genera these two muscles lie closely adpressed.

Quadratus femoris

This small muscle is so closely associated with the obturator externus that it is often difficult to distinguish it from the latter. Its innervation seems to indicate that it arose genetically from the latter. Still, it is present in even the most primitive genera as a small but definite element which exhibits little variation in extent or proportions throughout the order. Beddard (1895, p. 840) has badly confused this muscle, together with several of the other short muscles of the thigh.

Semitendinosus

No muscle in the thigh of the Salientia undergoes more radical change than the one I have designated in the more primitive genera as sartorio-semitendinosus (Plate VI, fig. 2). In the less specialized discoglossids, pipids, and pelobatids, this muscle retains its primitive super-

ficial position and has not split off its anterior part as the definitive sartorius. The posterior part of the sartorio-semitendinosus is divided in all forms, even in such primitive genera as *Ascaphus*. The most posterior portion lies deeper (more dorsal) than the anterior portion, whether or not this anterior portion has split off a sartorius. In the discoglossids, pipids, and pelobatids the sartorio-semitendinosus lies much more superficial than in any of the higher families. Moreover, its proximal end is very much broader and flatter than that found in the higher groups.

In both discoglossids and pelobatids, the proximal end of the sartorio-semitendinosus may be tendinous, especially the proximal end of the anterior portion. This occurs in the specialized genera of each family, as, for example, in *Pelodytes* (Plate XII, fig. 4). But even such generalized forms as *Ascaphus* (Plate VI, fig. 2) show some indication of the tendinous origin of this muscle. *Bombina*, *Alytes*, and *Discoglossus* have a very broad sheet of tendinous tissue attaching the anterior portion of the semitendinosus to the pelvis. The conditions in *Discoglossus* have been figured by Perrin (1892, fig. 34) and Nussbaum (1898, fig. 27). The tendinous portion is about as wide in *Alytes* and exactly as superficial. In *Bombina maxima* the anterior head is equally tendinous but in *B. igneus* it is more muscular.

The sinking of the two heads of the definitive semitendinosus deep within the thigh to the position they occupy in *Rana* must have taken place phylogenetically very gradually. Some bufonids and a few brachycephalids (*Atelopus*) represent intermediate stages between the conditions found in the pelobatids and that in the ranids. The relative position of the proximal heads of the semitendinosus is difficult to determine as well as somewhat variable. It cannot be used as a basis of classification. But the distal attachment, the insertion on the lower leg may be easily examined, and its position relative to the surrounding tendons and muscles is fairly constant in each natural group of genera. This will be discussed in more detail below.

Sartorius

As we have pointed out above, the sartorius arises by a division of the anterior part of the sartorio-semitendinosus of the more primitive genera. The actual morphogenesis is suggested by the conditions found in *Xenopus* (Plate X, fig. 2), but more particularly by that in *Bombina maxima* and *Discoglossus pictus*. The innervation also shows the close genetic relationship of sartorius and semitendinosus (compare Plate XVIII, figs. 1 and 2 with fig. 3).

No discoglossid possesses a sartorius distinct from the semitendinosus, nor does any pelobatid. The pipids, *Hymenochirus* and *Pipa*, likewise lack the sartorius, but *Xenopus*, more primitive than either genus in dentition, is more specialized in possessing a partly formed sartorius. The proximal end of this sartorius (Plate X, fig. 2) is not distinct from the semitendinosus, but the distal end is a very distinct tendon, as will be pointed out below.

All higher families of frogs and toads possess a sartorius. A detailed study of the distal tendons has revealed certain differences which will be discussed under a separate heading. The sartorius varies considerably in width and thickness in the various species. These differences in proportion are of no taxonomic importance.

Adductor magnus, caput ventrale

It has been pointed out above that the adductor magnus is composed primitively of two distinct muscles, which in the higher types tend to fuse distally. As these two muscles have very probably had a different origin, we have discussed each under separate headings. The more ventral and anterior of the two elements is present throughout the order. It exhibits considerable variation in proportion but very little in relative position. Primitively, as is well shown in *Pipa* (Plate VIII, fig. 2), *Hymenochirus* (Plate IX, fig. 2), and *Ascaphus* (Plate VI, fig. 2), the ventral head is a long muscle arising from the pubo-ischium immediately ventral to the obturator externus, and inserting on the distal end of the femur. In higher forms, the muscle becomes thickened; the proximal end looses its tendinous character; and the distal end secures a very broad attachment to the distal part of the femur. Although there is considerable variation, pipids and discoglossids agree in the main as regards the form and attachments of the ventral head. Pelobatids possess a more muscular element, while all the higher families possess the broad non-tendinous attachments characteristic of *Rana* (see Gaupp, 1896, fig. 101).

Semimembranosus

This muscle is subject to little change throughout the series. It varies somewhat in proportion but very little in relative position. In *Hymenochirus* and *Scaphiopus*, it is constricted longitudinally as if beginning to divide. But in neither *Pipa* or *Xenopus* is this constriction present, and in no salientian is the semimembranosus split into two definitive heads.

Gracilis major and minor

The gracilis major varies little in proportion or relations throughout the order but the gracilis minor is subject to extreme diversity. These differences seem to have little taxonomic value. The origin, insertion, and innervation (Plate XVIII, fig. 2) show that the gracilis minor is merely a slip of the gracilis major. In *Ascaphus*, only the proximal half is distinct from that muscle, while in *Hymenochirus* there is no gracilis minor present. Whether these two cases represent a retention of the primitive condition or whether they are due to secondary fusion cannot be stated. All other discoglossids and pipids, as well as all the higher families, possess a complete gracilis minor.

Beddard (1908*a*) has considered the attachment of the gracilis minor to the skin a feature of taxonomic importance. He would not have had to search very far to see the fallacy of this assumption. Not only do the brevicipitids, which Beddard has examined, but also most bufonids and all discoglossids show this attachment to various extents. In *Alytes obstetricans* and *Bombina maxima* among the discoglossids, and *Bufo* among the bufonids, the attachment is exceptionally broad. The greatest expansion of the gracilis minor occurs in *Rhinophrynus*, where it forms a panniculus carnosus wrapping around three sides of the femur (Plate XVI, fig. 6) and attaching along much of its proximal end to the skin. Altogether too much variation is shown in the degree of attachment among the members of even a single family such as the Bufonidæ to make the degree of this attachment a taxonomic character of any great importance.

The gracilis minor varies greatly in thickness. It is largest in *Pipa* and *Xenopus* and thinnest in some of the long-limbed ranids, hylids, and bufonids. Its development is not directly correlated with function. At least, the purely aquatic genera, *Batrachophrynus*, *Pseudis*, and *Xenopus*, vary greatly in the extent of its development. Still, it may be said that fossorial forms tend to have a greater expansion and attachment of the gracilis minor to the skin than do the terrestrial or aquatic genera.

Gemellus and Obturator internus

These two muscles may be considered together for they show very little diversity throughout the order. The conditions described and figured so well by Gaupp (1896) may be considered typical of the order. In *Pipa*, the pelvis is more triangular than in any of the other genera; the origin of the gemellus lies immediately dorsal to the obturator in-

ternus, directly beneath the semimembranosus. A slight shift of position such as this has no phylogenetic significance.

Pyriformis

There is no reason why the pyriformis should be so badly confused with other muscles as Beddard (1895, 1895*a*) has done. It originates in all genera where it is present from the tip of the coccyx (this may be bony or cartilaginous) and inserts on more or less of the posterior surface of the femur at a point about a fourth to a half its length, according to the species. Nussbaum (1898) showed that it was absent in *Pelobates fuscus*. It is also absent in *Pipa* and *Hymenochirus* (Plates VIII and IX), and represented by a very slender muscle in *Xenopus* (Plate X). In all other genera which I have examined for this feature (this does not include all the species listed under the discussion of the distal tendons), the pyriformis is present. I have examined numerous forms in every family, and it may be safely said that the presence or absence of the pyriformis has no taxonomic value.

Caudalipuboischiotibialis

The most surprising discovery made during my study of the thigh muscles of the Salientia was the finding of a tail muscle in addition to the pyriformis attaching to the thigh of *Ascaphus*. We have seen some reason above to consider this genus (possibly with *Bombina*) the most primitive of existing Salientia. It has been assumed for many years that the Salientia arose from tailed ancestors; that pelvic musculature of the Pro-Salientia was probably not unlike that of the urodele; and that the pyriformis of existing Salientia is a compound muscle having resulted from a fusion of the two urodelian tail muscles, caudalifemoralis and caudalipuboischiotibialis. It now appears that *Ascaphus*, alone of all the Salientia, possesses both these urodelian tail muscles in practically their original position. This is a startling fact, for it demonstrates that the Pro-Salientia very probably retained their tail until fairly recently in the history of the order and, further, it gives us a fairly definite landmark in homologizing the thigh muscles of the frog with those of the salamander.

Ascaphus has long been known as possessing a "tail" in the adult male. Arldt (1917, p. 118) has recently fallen into the error of considering this structure a larval tail retained in the adult, direct evidence of the lowly position of *Ascaphus* among discoglossids. The most superficial examination of a specimen of *Ascaphus* (Plate V) will demonstrate that this structure cannot be a true tail, since it is in no way associated

with the vertebral column and the cloaca opens near its tip. In fact, none of the investigators who have studied *Ascaphus* have considered it a true tail. But, specimens of *Ascaphus* have been very rare and no one until this time has studied its structure or discussed its function.

I have had the opportunity of examining several live specimens of male *Ascaphus* sent to me by mail across the continent from the Olympic Mountains, Washington. Their "tails" were slightly variable in proportion, as is well shown in the several figures (Pl. V). The tail is a very soft structure, examined to the best advantage when floating in water. It is obviously highly vascular and turgid with blood, for the unpigmented ventral surface is of a pinkish hue. When floating in water, it is roughly pyramidal in shape, with a very definite terminal point.

Removal of the skin confirmed the opinion that the "tail" is purely a cloacal organ. It consists chiefly of an outer and an inner layer of muscular tissue. The outer layer is free both dorsally and laterally from the inner layer. The vascularity is greatest distally and ventrally. The inner wall of the deep layer, in other words, the surface of the cloaca, exhibits numerous longitudinal furrows. The ventral surface of the "tail" after removal of the skin shows an hour-glass-shaped structure (Plate VI, fig. 2). The rectus abdominis seems to form the anterior part of this structure. Further dissection demonstrated that the structure owed its form to two cartilages which, like a pair of scissor-forceps, reached out to grasp the end of the "tail" (Plate VII).

A comparison of the "tail" with the cloacal region in the other Salientia has convinced me that the inner layer represents the sphincter ani cloacalis of other genera. The outer layer seems to be a muscle which I have found very pronounced in *Scaphiopus* (Plate XI, fig. 1) and *Rhinophrynus* (Plate XIII). I have called it the ischio-cutaneus for want of a better name. The ischio-cutaneus is present as a very incipient structure in *Bombina*. It is apparently a portion of the sphincter ani cloacalis which has become attached ventrally to the ischium and dorsally to the skin. The ventral surface of the "tail" is firmly attached to the cartilaginous prongs (Plate VII, fig. 3) which very probably represent a specialized portion of the rectus abdominis. The female *Ascaphus* does not help us in determining these homologies for the "tail" is already differentiated, although very rudimentary.

I have given this cursory sketch of the structure of the "tail" of *Ascaphus* to demonstrate that it is a very specialized cloacal structure and bears no relation to the coccygeal muscles of that genus. One would

imagine, of course, that the "tail" must be an intromitant organ. Field observation alone will prove this point. I may emphasize, however, that the organ is so large that even in the freshly killed specimen not more than the point can be inserted into the cloaca of the female. It is conceivable that the lips of the male cloaca might be so adpressed that the spermatozoa could be squirted directly into the cloaca of the female when the pair is in copulation. Still, it is extremely probable that internal fertilization does not take place and that the "tail" acts merely as a directing organ. In such a capacity it might be very useful. I have often watched the oviposition of *Hyla crucifer*. The female sticks each egg (sometimes more than one is emitted at a time) as it leaves the cloaca to a bit of waterweed or other object. To do this her cloaca must in general be bent well up under the body. The cloaca of the male at this moment is in practically all cases more than an inch from the cloaca of the female. But, just as the egg is laid, he brings the rear part of the body forward with a sudden jerk and emits a jet of spermatozoa. It should be noted that the only strong muscle in the "tail" of *Ascaphus* is the ventral one. It is probable that the "tail" is moved in only one direction, i.e., directly beneath the body. It seems to me that, if *Hyla crucifer* were provided with a "tail" such as *Ascaphus*, fertilization would be greatly facilitated.

To return from the speculative to the descriptive, it may be added that the caudalipuboischiotibialis of *Ascaphus* attaches to the inscriptio-tendinea of the semimembranosus exactly as the caudalipuboischiotibialis of the salamander attaches in part to a small inscriptio of the ischio-flexorius (Plate XVII). We shall show reason below for homologizing the semimembranosus with the ischio-flexorius. It may be noted at this point that there is good reason for applying to this additional coccygeal muscle the name of a salamander tail muscle. No mammalian name can be applied to it, for there is good reason to believe that the caudalipuboischiotibialis drops out in the Reptilia just as it has done in all frogs except *Ascaphus*. The pyriformis is a well-developed muscle in *Ascaphus*. There is no longer need of considering it a duplex muscle in the Salientia. All the evidence seems to indicate that the caudalipuboischiotibialis has dropped out in all genera higher than *Ascaphus* and has not fused with the pyriformis, as has been hitherto assumed.

Cruralis and Glutæus

Gaupp (1896, p. 177) groups these two muscles, together with the tensor fasciæ latæ, under the name triceps femoris. As we shall see

below, the tensor fasciæ latæ has no genetic relation to the cruralis and glutæus. These two muscles are undoubtedly the two heads of a single muscle. There is a tendency, especially in the pelobatids, for the splitting off of a third posterior head. Nussbaum (1898, p. 381) has described in some detail this muscle in *Pelobates fuscus*. In *Scaphiopus* it has much the same relations. This third, or accessory head, is not peculiar to the pelobatids. An incipient condition is found in several bufonids. It is interesting that even in its incipient stages, as in *Acris* (Plate XIX, fig. 1), the accessory head is supplied chiefly by a separate nerve from the trunk innervating the cruralis and glutæus.

The small differences in proportion exhibited by the cruralis, glutæus, and accessory head (when present) throughout the series of forms examined have no taxonomic value. The conditions found in *Rana* may be considered characteristic of the order.

Iliofemoralis and Iliofibularis

These two muscles may be considered together, not because of any genetic relationship but because neither shows any great variation throughout the order. The exact point of origin is somewhat variable. In *Rana*, both muscles arise from a single tendon. In other genera, such as the primitive *Bombina* and *Ascaphus*, the iliofemoralis seems to wrap partly around the head of the iliofibularis and attach to the ilium dorsal to the latter muscle. In *Pipa*, the iliofemoralis arises partly from the tendon of the iliofibularis and partly posterior to it. In most Salientia, the two muscles originate from practically the same point, and if their proximal tendons are not fused, that of the iliofemoralis is dorsal to that of the iliofibularis. Slight shiftings in the relative position of these proximal tendons seem to have no phylogenetic importance.

Distal Tendons of the Thigh

It was noticed long ago by DeMan (1873, 1874) that there is a considerable difference in the relative arrangements of the distal heads of the sartorius, semitendinosus and gracilis major in *Rana* as contrasted to those in *Hyla* and *Bufo*. Nussbaum (1898) has considered these differences in more detail and has brought out other differences found in *Pelobates* and in *Discoglossus*. Beddard (1907, 1907*a*) has discussed certain of these features in the pelobatids which he examined. But no investigator has examined more than a few genera, and none of these authors with their limited series were in a position to discuss these features from either a phylogenetic or a morphogenetic point of view. I

have brought together a huge series of species and have succeeded in determining certain constant differences which alone might serve to define natural groups. I may anticipate my conclusions by stating that the differences exhibited by the insertions of these thigh muscles lend considerable support to the classification which I have proposed on totally different grounds in the first part of this paper. This agreement of two such diverse lines of evidence has led me to the conclusion that we have now before us for the first time a natural classification of the Salientia.

Rana, which has been considered the typical salientian in most morphological work, is the most specialized in regard to the insertions of the posterior thigh muscles, just as it is the most specialized in many other ways. I have represented the conditions as found in *Rana clamitans* in Plate XIV, fig. 3. It will be noticed that the gracilis major and minor dip under the tendon of the sartorius to insert on the head of the distal end of the femur. Further, the head of the semitendinosus lies entirely dorsal (deep) to the gracilis major and minor. This complex we may call the ranid type. By way of contrast, we may examine the conditions of *Leptodactylus pentadactylus* (Plate XIV, fig. 2). Here the sartorius attaches to the distal tendon of the semitendinosus, which is ventral (superficial) to the common tendon of the gracilis major and minor. We may speak of this complex as the bufonid type. The fundamental difference, then, between the ranid and bufonid types is that in the latter the head of the semitendinosus crosses outside (superficial) to that of the gracilis major and minor while in the ranid type it has in some way secured a position on the inside (deep) to this tendon; while the sartorius, which in the bufonid type attached to the head of the semitendinosus, in the ranid type attaches to the knee. This might not seem a great difference if the distal tendons were subject to a shifting of their insertions. But within a family these insertions are remarkably constant, regardless of the diverse habits of the species in the group. All of the ranids which I have examined have these distal tendons in precisely the arrangement which I have described for *Rana clamitans*. There are some differences in the degree of development of certain binding and connecting ligaments. We shall discuss these in more detail below. These secondary ligaments neither alter nor confuse the arrangement of the distal tendons, which remains constant throughout the family. I have examined one or more specimens of each of the following species of ranids and find no deviation from the ranid type: *Rana æsopus*, *R. albolabris*, *R. clamitans*, *R. cyanophlyctis*, *R. fasciata*, *R. fus-*

cigula, R. goliath, R. limnocharis, R. mascareniensis, R. pileata, R. pipiens, R. signata, R. virgatipes; Babina holsti; Ceratobatrachus guentheri; Scotobleps gabonicus; Leptopelis[1] *aubryi, L. anchietæ, L. calcaratus, L. rufus; Cornufer corrugatus, C. guppyi; Leptodactylodon ovatus; Petropedetes newtonii; Chiromantis rufescens, C. xerampelina; Astylosternus robustus; Gampsosteonyx batesii; Phyrnobatrachus bonebergi,*[2] *P. boulengeri, P. dendrobates, P. natalensis, P. perpalmatus, P. plicatus; Arthroleptis batesii, A. pœcilonotus, A. variabilis, A. wahlbergii; Sooglossus seychellensis; Megalixalus fornasinii, M. immaculatus, M. spinosus; Kassina senegalensis; Cardioglossa leucomystax; Dimorphognathus africanus; Hyperolius concolor, H. picturatus, H. steindachneri; Polypedates dennysii, P. goudoti, P. japonicus, P. leucomystax, P. maculatus maculatus, P. m. quadrilineatus, P. mocquardi, P. reinwardtii, P. viridis; Hazelia spinosa; Oxyglossus lævis martensii, O. lima; Mantella ebenaui; Staurois natator; Platymantis solomonensis; Philautus leucorhinus, P. pictus; Nyctibatrachus pygmæus; Nannophrys ceylonensis,* and *Nannobatrachus beddomii.*

The opinion has been expressed in the first part of this paper that the Brevicipitidæ (as defined above) are closely allied to the Ranidæ, being distinguished from them only by the dilation of the sacral diapophyses. It was to be expected, then, that, if the numerous genera of ranids considered above exhibited no variation in the insertions of the muscle heads under consideration, the Brevicipitidæ would also show no variation but would agree with the ranid type. This is exactly what I have found to hold true. All brevicipitids which I have examined exhibit the ranid type of distal tendon complex. I have dissected at least one specimen of the following species of Brevicipitidæ: *Breviceps gibbosus, B. mossambicus; Kallula mediolineata, K. pulchra, K. verrucosa; Kalophrynus pleurostigma; Glyphoglossus molossus; Phrynomantis bifasciata; Microhyla berdmorii, M. butleri, M. inornata, M. leucostigma, M. pulchra; Cacosternum boettgeri; Anhydrophryne rattrayi; Cacopoides borealis; Rhombophryne testudo; Pomatops valvifera; Hemisus guttatum, H. marmoratum; Mantophryne lateralis; Phrynella pulchra; Sphenophryne anthonyi, S. celebensis, S. loriæ, S. monticola, S. verrucosa; Calliglutus smithi; Plethodontohyla notosticta; Caluella guttulata; Hypopachus cuneus, H. pearsei, H. variolosus; Otophryne robusta; Stereocyclops incrassatus; Gastrophryne carolinensis, G. texensis, G. ovalis, G. usta.*

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[1]For use of this name see Noble (in manuscript).
[2]I have discussed the status of this species in the paper referred to above (Noble, in manuscript).

The bufonid type of complex is not restricted to the Bufonidæ but occurs also in the Brachycephalidæ and the Hylidæ. In other words, the suborder Procœla is characterized by the bufonid type of complex. We have seen above that the suborder Diplasiocœla (Ranidæ and Brevicipitidæ) is characterized by the ranid type. Further, all Diplasiocœla possessed a typical ranid type of complex in spite of the diverse habits of the species. All the Procœla do not exhibit the typical bufonid type. The vast majority possess the typical condition but a few exceptions occur. These are not damaging to our scheme of classification, for the variations are but modifications of the bufonid plan. The following Procœla possess the typical bufonid tendon complex (Plate XIV, fig. 2): *Leptodactylus caliginosus, L. gracilis, L. lineatus, L. melanonotus, L. mystacinus, L. ocellatus, L. olfersi, L, pentadactylus, L. prognathus, L. typhonius; Pseudis mantidactyla, P. paradoxa; Eleutherodactylus briceni, E. conspicillatus, E. longirostris, E. polyptychus, E. ranoides, E. richmondi, E. unistrigatus, E. wightmanæ; Syrrhophus campi, S. ridens; Ceratophrys americana, C. ornata; Borborocœtes bibronii, B. miliaris, B. nodosus, B. quixensis, B. rosius; Paludicola bufonia, P. fuscomaculata, P. pusilla; Pleurodema bibronii, P. nitida; Batrachophrynus microphthalmus; Hyloscirtus boulengeri, H. fuhrmanni; Centrolene geckoideum; Centrolenella antioquiensis; Zachænus parvulus; Elosia vomerina; Eupemphix pustulosus, E. trinitatus; Heleioporus albopunctatus, H. pictus; Philocryphus flavoguttatus; Mixophyes fasciolatus; Phractops alboguttatus, P. australis, P. platycephalus; Limnodynastes dorsalis, L. olivaceus, L. peronii; L. salminii, L. tasmaniensis; Hyla andersonii, H. arenicolor, H. aurea, H. baudinii, H. bipunctata, H. boans, H. boulengeri, H. caerulea, H. dolichopsis, H. elegans, H. evittata, H. eximia, H. gracilenta, H. infrafrenata, H. maxima, H. minuta, H. punctata, H. raddiana, H. rosenbergi, H. variabilis, H. wilsoniana, Pternohyla fodiens; Agalychnis helenæ; Phyllomedusa bicolor, P. burmeisteri, P. dacnicolor, P. hypochondrialis, P. tarsius; Gastrotheca marsupiatum; Cerathyla johnsoni, Bufo macrotus, B. marinus, B. melanostictus, B. penangensis, B. polycercus, B. punctatus, B. raddei, B. rostratus, B. simus, B. stelzneri,[1] B. tuberosus, B. typhonius; Notaden bennetti; Pseudobufo obscurus; Nectophryne afra, N. batesii, N. guentheri, N. signata; Brachycephalus ephippium; Sminthillus lim-*

[1] *Bufo stelzneri* is well known in the literature under the name of *Phryniscus nigricans* Duméril and Bibron (*nec* Wiegmann). *Phryniscus* of Wiegmann was shown by Boulenger (1894, p. 374) to be a *Bufo*. The name *Phryniscus* was shown to be untenable and Boulenger referred the species to *Atelopus* Duméril and Bibron. Boulenger (*loc. cit.*) found it necessary to change the specific name to *stelzneri*. It has appeared to me on dissection that *A. stelzneri* is a true *Bufo*, possessing all the generic structures of that group. The genus *Atelopus* was based on *A. flavescens*, a firmisternal form, and should be retained for all other species, save *stelzneri*, which have recently been referred to that group.

batus, S. peruvianus; Geobatrachus walkeri; Rhinoderma darwinii; Oreophrynella quelchii; Atelopus carrikeri, A. elegans, A. flavescens, A. gracilis, A. ignescens, A. oxyrhynchus, A. varius.

The simplest type of deviation from the bufonid plan of tendon complex is that found in *Rhinophrynus* (Plate XVI, fig. 6). It has already been mentioned that in this genus the gracilis minor is enormous and wraps around the greater part of the knee. This expansion of the gracilis minor has apparently caused a slight shifting of the insertion of the gracilis major, which attaches to the outer (ventral) side of the tendinous head of the semitendinosus instead of passing under it (dorsal). This slight modification of the bufonid plan of complex is found in no other Salientia. It cannot be considered of any great importance.

A remarkable change in the insertions of the thigh muscles lying on the posterior side of the thigh occurs within certain genera of bufonids. For example, *Pleurodema bibronii* (Plate XV, fig. 1) exhibits these distal heads in their typical bufonid arrangement (compare with *Leptodactylus pentadactylus*, Plate XIV, fig. 2). But in *Pleurodema cinerea* (Plate XV, fig. 2) the tendon of the semitendinosus has cut its way into the center of both gracilis major and minor and its distal end pierces both these muscles to attach to the lower limb. In *P. brachyops* the head of the semitendinosus had proceeded a step further in its migration into the deeper part of the leg. In this species it does not pierce the gracilis major but lies entirely dorsal (deep) to it (Plate XV, fig. 3). Its relationship to the gracilis minor is about the same as that in *P. cinerea*.

Another case of the inward migration of the tendon of the semitendinosus occurs in the Australian genus *Limnodynastes*. *L. dorsalis* possesses the typical bufonid arrangement. In *L. ornatus* (Plate XV, fig. 4) the tendon pierces both the gracilis major and minor very much as in *Pleurodema cinerea* (Plate XV, fig. 2). We may consider the arrangement seen here in *L. ornatus* and *P. cinerea* as the first stage in the inward migration of the tendon of the semitendinosus. The insertion of the semitendinosus is changed very little by this migration. The tendon has apparently become pulled within the gracilis muscle mass and, in doing so, it has left the sartorius attached to the knee. Just what factors have forced the inward migration of the tendon it is impossible to say. It is remarkable that the phenomenon has occurred in so few forms.

The extreme stage of this tendon migration as found in the Procœla is exhibited by *Pseudophryne australis* (Plate XV, fig. 5). In this form, the tendon of the semitendinosus does not pierce the muscular part of the gracilis mass but only the ligamentous head. Conditions are very

similar in *Hyloxalus* (Plate XV, fig. 6). Here it is more apparent that the tendon has migrated through the muscular gracilis major and minor and has become bound by their secondary ligaments. *Dendrobates* and *Phyllobates* exhibit an identical arrangement of these elements.

It will be noticed that this extreme stage of tendon specialization found in the Procœla is not very different from the ranid type of complex, which I have already indicated as peculiar to the Diplasiocœla. The difference, although small, seems to be constant. I have found none of the Procœla with the tendon of the semitendinosus free from the gracilis mass, or, in other words, in the typical ranid position. I have mentioned above that the Ranidæ exhibit a great variation in the development of binding and secondary ligaments. I use the term "binding" for ligaments which hold the tendon of the semitendinosus to the gracilis mass (Plate XV, fig. 5), while I designate those ligaments as "secondary" which run between the main heads of the thigh muscles and do not function in the insertion of those heads. I have found a binding ligament well developed in very few Diplasiocœla, perhaps best in *Astylosternus robustus*. But even here the tendon is not tightly bound to the gracilis mass as in the specialized Procœla; further, it lies more posterior to the head of the gracilis major. Typically, there is no binding ligament present in the Diplasiocœla, or at best a very weak, nontendinous one (Plate XVI, fig. 1). The variations in form and attachment of the secondary ligaments do not concern us here for these variations have no taxonomic value.

There can be little doubt that the Diplasiocœla developed their peculiar type of tendon complex by carrying conditions similar to those found in the most specialized types of Procœla a step further. The step is not a great one, and it may be asked if the specialized types of Procœla could not have developed their tendon complex by a modification of the ranid type. Leaving aside all other evidence, osteological, distributional, etc., it still seems extremely unlikely, for the Diplasiocœla, as we have seen above, are extraordinarily stable in regard to their distal tendons. In no case do we find any muscle fibers from the gracilis binding the tendon of the semitendinosus, and in very few cases do we find a ligament in this position. It does not seem likely that a "reversion" of evolution could have taken place in the morphogenesis of the distal tendons of any of the Procœla.

I have examined the following species of Procœla showing conditions intermediate between the bufonid and ranid types of tendon complexes. These species may be roughly grouped into less specialized, Grade A

(Plate XV, fig. 4), and more specialized, Grade B (Plate XV, fig. 5), types.

Grade A.—*Limnodynastes ornatus; Pleurodema brachyops, P. cinerea, P. marmorata; Crinia georgiana, C. signifera; Uperolia marmorata.*

Grade B.—*Pseudophryne australis, P. bibronii, P. coriacea; Adelotus brevis; Dendrobates braccatus, D. parvulus, D. tinctorius, D. trivittatus, D. typographus; Phyllobates alboguttatus, P. infraguttatus, P. inguinalis, P. subpunctatus; Hyloxalus collaris, H. fuliginosus, H. granuliventris.*

The Opisthocœla and Anomocœla exhibit the most primitive type of tendon complex. In this, the head of the sartorio-semitendinosus crosses outside (ventral) of the head of the combined gracilis tendon to insert on the lower leg (Plate XIV, fig. 1). From this, the bufonid complex was evolved by the mere splitting off of the sartorius head without a shifting of its insertion.

The Anomocœla show little deviation from the discoglossid type of tendon complex. In *Scaphiopus* the gracilis minor attaches in part to the tendon of the semitendinosus. This gives a peculiar appearance (Plate XI, fig. 2).

The pipids exhibit a remarkable specialization in their distal thigh tendons. In *Xenopus* only the distal half of the sartorius has separated from the expanded sartorio-semitendinosus and yet *X. tropicalis* (Plate XVI, fig. 4) exhibits an arrangement of the tendons practically as specialized as in *Pleurodema cinerea* (Plate XV, fig. 2), while *X. mülleri* (Plate XVI, fig. 5) has carried the specialization a step further to the typical ranid type. An early stage in the migration of the tendon of the semitendinosus through the gracilis mass is well shown in *Pipa*. In brief, the Pipidæ do not retain the primitive complex of the Discoglossidæ, but have specialized along exactly the same stages found in the other Salientia. This is a striking case of orthogenetic variation.

It may be argued that if the pipids with at best half a sartorius can undergo all the modifications found in the distal tendons throughout the Salientia as a whole, little faith can be placed in these modification in determining our groups of higher Salientia. An examination of these higher genera has shown an extraordinary stability of these tendons. In some way we must account for the fact that the Bufonidæ, Hylidæ, and Brachycephalidæ possess one type of complex, while the Ranidæ and Brevicipitidæ possess another. I have accounted for this discrepancy by assuming that the first three families embrace a natural group

of genera unrelated to those of the last two families. In this assumption I have the support of comparative osteology.

I have examined the distal tendons of the thigh on the following species of Anomocœla: *Scaphiopus hammondii, S. holbrookii; Pelobates cultripes, P. fuscus; Pelodytes punctatus; Megalophrys feæ, M. hasseltii, M. major, M. montana, M. nasuta, M. parva, M. longipes, M. pelodytoides, M. böttgeri; Xenophrys monticola.*

The following species of Opisthocœla have been studied in regard to their tendons: *Ascaphus truei; Bombina igneus, B. maxima; Discoglossus pictus; Alytes cisternasii, A. obstetricans; Xenopus mülleri, X. tropicalis; Pipa pipa; Hymenochirus boettgeri.*

Discussion and Summary

From the above, it is apparent that the thigh musculature supports our conclusions, derived from a study of the osteology, that the Opisthocœla and Anomocœla are more primitive than the Procœla and Diplasiocœla. The structural features in the thigh of the two former suborders which are indicative of the stem position of these groups may be listed as follows.

(1). Absence of a sartorius (partly present in *Xenopus*).
(2). Semitendinosus broad and superficial to other muscles.
(3). Adductor longus typically undifferentiated, but present in the more specialized genera.
(4). Accessory head of iliacus externus retained.
(5). Adductor magnus composed of two muscles distinct for practically their entire length (except some discoglossids); no accessory head present.
(6). Obturator externus well developed.

There are many structural features which distinguish the two more primitive suborders from the more advanced groups or from one another, but there are few characters distinguishing the Procœla from the Diplasiocœla. It is, therefore, very interesting that the Diplasiocœla should be found to be characterized by a distinctive type of tendon complex in the distal part of the thigh, while most Procœla should be distinguished by a much more primitive type. A few Procœla have this complex modified to approach that characteristic of the Diplasiocœla. But even here, there is a gap between them which is not bridged over. Thus the arrangement of the distal tendons of the thigh groups all the higher Salientia into two categories, two great natural groupings. It is highly significant that these two categories should agree exactly with the two which we have already distinguished on the basis of the vertebral column.

From a morphological standpoint, perhaps the most interesting

discovery made during the study was the finding of two pairs of coccygeal muscles in *Ascaphus*, the anterior homologous to the caudalifemoralis of the salamander and pyriformis of the other Salientia, while the posterior is represented in no other salientian although undoubtedly homologous to the caudalipuboischiotibialis of the urodeles. This extra pair of tail muscles has been shown above to have no relation to the "tail" of the male *Ascaphus*, which is purely a copulatory apparatus. The extra muscles may well be considered vestigial structures, even if not entirely functionless ones.

Lastly, a word may be said in regard to the generalized salientians. If one is dealing with doubtful structures, the common frog, *Rana*, would be apt to prove the most confusing member of the order for, in many ways, it is the most specialized. This holds especially true for the thigh muscles. It would appear only from examining representatives of the more primitive families that the adductor longus was merely a specialized slip of the pectineus; the sartorius, the anterior portion of a formerly superficial and broad semitendinosus; the adductor magnus, a composite of two distinct muscles which have fused and finally separated off an accessory head. The less specialized discoglossids, *Ascaphus* and *Bombina*, or even some of the pelobatids possess a thigh musculature which may be considered sufficiently generalized to form a prototype or pattern from which all the more advanced types of thigh musculature may have arisen.

HOMOLOGIES OF THE THIGH MUSCLES

General Considerations

It is obvious that, if the thigh muscles of the Salientia are to be homologized at all with those of other vertebrates, they should be compared first with those of the salamander, since the salamander is the nearest living relative of the Salientia possessing appendages. It has been possible to homologize the muscles of man with those of the marsupials and to trace their apparent homologies through to the urodeles. The frog is obviously very specialized in its locomotory apparatus. Direct comparison with man or even reptiles present serious difficulty unless we are sure of the homology in the urodeles.

Until now we have been by no means sure of these homologies. Various attempts have been made to homologize the thigh muscles of the frog with those of the urodele. Perhaps the most extensive of these attempts have been made by DeMan (1873) and Perrin (1892). These attempts have not been successful for one or more of the following reasons.

(1). Primitive frogs have not been compared with primitive salamanders. The conditions found in the genus *Rana* have been accepted as typical of the order.

(2). Mistakes have been made in determining the innervations of the muscles, or the nerves have not been considered at all.

(3). Certain muscles in the thigh of the salamanders have not been recognized as distinct from others. The range of variation within the urodeles has not been understood.

(4). The absence of an obturator foramen and obturator nerve in the frog has removed one landmark of considerable importance in determining homologies.

From what has been said above, it is obvious that there is a great range of differences among the various groups of Salientia. In making our comparisons, we should necessarily select a little specialized form such as *Ascaphus* and not a ranid. It will appear from the figures that the primitive type of musculature in the thigh of the Salientia is not very different from that of the urodele. This is not surprising in that the Salientia have apparently evolved from the rhachitomous labyrinthodonts and the pelvis of such a form as *Eryops*, although somewhat compressed, is essentially like that of the urodele type. A study of a beautifully preserved pelvis of *Eryops* in the American Museum has led me to place the muscle origins in the positions indicated in Plate XXII, fig. 2. By comparison with Plate XXII, fig. 1, it will appear that this musculature

is not very different from that of the urodele. It seems probable from a study of this pelvis that the immediate ancestors of the Salientia possessed a thigh musculature similar to that of the urodele. The musculature of the less specialized discoglossids approaches this urodele type. The homologies of the muscles are best understood by comparing these primitive frogs with the urodele.

The Thigh Musculature of the Urodeles

A detailed description of the thigh musculature of a salamander for comparison with that of a frog might seem superfluous with the numerous accounts of urodelan myology available. There are, to be sure, a few discrepancies in some of these accounts. It would not appear from these accounts that the thigh muscles of all salamanders, save those of the Proteidæ, are essentially alike, differing only in development and extent of the same set of elements. Nor is this misconception of the uniformity of the urodele thigh muscles due entirely to the diverse nomenclatures used by the various authors. One element, the adductor femoris (Perrin), has been overlooked by all but one of the investigators, while two elements, the iliotibialis and the ilio-extensorius, have been generally taken for a single one by authors considering the advanced types. Thus, these two elements are considered one in several forms recently investigated by Sieglbauer (1904). Not only do they have a different innervation but, without exception, they have a different origin. In some urodeles, the distal ends insert into a common tendinous sheath. But, as this sheath is generally two-headed, I consider it formed in part by a coalescense of the distal tendons of the two muscles which throughout their length are nearly always distinct. It is surprising that the distinctness of these two muscles has not been universally accepted. In all probability this is due to the fact that none of the investigators have examined a wide range of species. In selecting my series I have tried to secure as many diverse types as possible. The following species have been examined: *Salamandra salamandra; Triturus cristatus, T. alpestris, T. viridescens; Notophthalmus torosus; Tylototriton verrucosus; Pachytriton sinensis; Rhyacotriton olympicus; Dicamptodon tenebrosus; Ambystoma tigrinum; Aneides lugubris; Pseudotriton ruber, Desmognathus quadra-maculatus; Megalobatrachus maximus; Cryptobranchus alleganiensis; Amphiuma means; Necturus maculosus; Proteus anguinus;* and *Typhlomolge rathbuni.*

With this series before me it can be definitely stated that there is very probably a constant number of elements in all urodeles except the

Cryptobranchidæ, which exhibit a nearly complete fusion of the puboischiotibialis and pubotibialis, and the Proteidæ, which do not have the adductor femoris distinct from the pubotibialis. It is not my purpose to discuss here the variations in proportions of the thigh muscles as exhibited in the various species. The description of the thigh musculature given by DeMan (1873) for *Triturus cristatus* or by Wilder (1912) for *Necturus* might serve our purposes if these and the various other authors had laid sufficient emphasis on the distinctness of two muscles important for us in a study of homology.

In all of the salamanders which I have examined, the iliotibialis[1] arises on the anterior edge of the ilium and never on the outer face where it might be confused with the ilio-extensorius. Its proximal head may be attached either well up on this anterior edge of the ilium (most salamanders) or, in aquatic forms, may shift to a very low point on this anterior edge, as in *Megalobatrachus*, where a few fibres may trespass on to the pubis.

The insertion of the iliotibialis is much more variable than its origin. It is due to the fact that the distal end of the iliotibialis is often closely associated with the ilio-extensorius that these two muscles have been confused. Thus, in *Typhlomolge rathbuni*, where the appendages are greatly elongated and the muscles consequently narrowed, the iliotibialis and ilio-extensorius are not readily separable distally. They are also closely adherent in *Triturus alpestris* but in *Triturus cristatus* they are quite distinct. In the majority of salamanders, these two muscles are associated as indicated in the figure of *Rhyacotriton* (Plate XVII, fig. 2). But in *Cryptobranchus* (Plate XVII, fig. 1) and *Megalobatrachus*, the iliotibialis and ilio-extensorius are not at all in contact. In *Proteus anguinus*, the iliotibialis is associated distally with the head of the puboischiofemoralis internus, from which, as we shall discuss below, the muscle has very probably arisen. It is interesting that the Cryptobranchidæ should have the iliotibialis and ilio-extensorius so widely separated. The two genera included in this family are closely related to primitive Hynobiidæ. The wide separation of the iliotibialis and ilio-extensorius seems to me to be a primitive feature. This does not seem to have been recognized by the various writers (Humphry, Mivart, and Osawa) who have considered the myology of *Cryptobranchus* or *Megalobatrachus*.

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[1] I follow Wilder in the use of this name; the iliotibialis of DeMan includes both this element and the ilio-extensorius.

The second muscle which has been generally overlooked is one designated by Perrin (1892) as the "Adducteur du fémur" (Plate XVII, figs. 12, 13, and 14, muscle No. 117). Dugès (1834) did not distinguish this muscle from the puboischiofemoralis externus; Humphry, DeMan, and Hoffmann considered it part of the puboischiofemoralis internus. Neither Mivart (1869) nor Osawa (1904) recognized that the great sheet on the ventral surface of the thigh of the cryptobranchids is formed by the nearly complete fusion of the puboischiotibialis and the pubotibialis. That there is actually a fusion is shown by the innervation, but especially by the fact that certain ambystomids and salamandrids have the puboischiotibialis and pubotibialis closely adpressed and bound together by connective tissue. Directly dorsal to the anterior portion, which must be recognized as the pubotibialis, lies a well-developed muscle, distinct distally from both the puboischiofemoralis externus and internus. This is the adductor femoris. Mivart, Humphry, and Osawa confused the muscle with one of those lying adjacent to it. In all the genera of salamanders which I have examined except *Proteus* and *Necturus*, I have found the adductor femoris present, lying immediately dorsal to the pubotibialis and between the puboischiofemoralis externus and internus. In these two genera it is apparently fused with the pubotibialis. It cannot be stated offhand that this undifferentiation of the adductor femoris is a larval condition, just as many of the other structural peculiarities of this family. *Typhlomolge rathbuni*, which is certainly a neotenous plethodontid, has a well-developed adductor femoris.

The adductor femoris is not always as distinct as it is in the forms studied by Perrin. In *Megalobatrachus*, which has the greater part of the pubotibialis fused with the puboischiotibialis, as in *Cryptobranchus*, the adductor femoris is a very large muscle, distinct from the puboischiofemoralis externus distally, but more or less fused with it proximally. This apparent fusion is not surprising in a salamander where the muscle bundles are so loosely grouped into definitive muscles. In *Dicamptodon tenebrosus*, the puboischiotibialis is massive, the puboischiofemoralis externus is narrow and broadly overlaps the adductor femoris. In *Triturus cristatus* and *T. alpestris*, the adductor femoris is long and narrow. Its proximal head, as usual, arises from the pubis directly beneath (as viewed ventrally) the pubotibialis. Its distal head inserts on the femur considerably proximal to that of the pubotibialis. In *Pachytriton sinensis*, the adductor femoris is very distinct distally from the pubotibialis but proximally some of its fibres may run into it. It would seem that this fusion of the two elements, carried to an extreme in the

Necturidæ, may represent a primitive condition and that the adductor femoris arose phylogenetically from the pubotibialis. The innervation of the two muscles is so distinct that this separation could not have taken place very recently. Perhaps the extreme specialization of the thigh musculature is found in *Typhlomolge*, where the legs are greatly elongated and have been stated to function as feelers or balancers as much as limbs. In *T. rathbuni*, the pubotibialis is narrow and tendinous. It lies directly over (as seen from below) the adductor femoris, which is well developed and stands out in striking contrast to the very much shortened puboischiofemoralis externus.

In brief, the thigh muscles of all salamanders are essentially the same. In the Cryptobranchidæ, the puboischiotibialis is nearly completely fused to, or at least bound together with, the pubotibialis; in the Necturidæ, the adductor femoris is completely fused with the pubotibialis. In all other salamanders, variations include only differences of proportion and relative position. In the Cryptobranchidæ, the iliotibialis has succeeded in shifting its origin downward along the anterior edge of the ilium. Primitively, the iliotibialis was perfectly distinct from the ilio-extensorius with which it has become associated distally in some forms.

Nerve Supply

Here again it is not our intention to discuss in detail any nerves except those which have been overlooked or incorrectly identified. With the acetic-osmic method it has been possible to pick out both inter- and intra-muscular nerves. This method not only assures accuracy and speed in the identification of the nerves trunks, but it also gives us for the first time a simple means of picking out a nerve fibre for practically its entire length, that is, for the length ot its myelin sheath.

The acetic-osmic method was first used extensively by Nussbaum. But he (1898) succeeded in staining very few of the intra-muscular nerves. In 1909, Müller, working with elasmobranch material, claimed he was able to stain every nerve "von Anfang zu Ende" by means of this method. Müller implied that the acetic-osmic method was original with him but, as his method differs but little from that of Nussbaum, it is surprising that he was able to secure so much better results. Braus (1910), using the same material as Müller, denied many of Müller's conclusions and contended that the acetic-osmic method was useless for determining intra-muscular innervations. The probability is that both Braus and Müller are right in part. I find that results vary enormously

on slight variations in the technique. With amphibian material intra-muscular nerves may be well stained if the specimens are sufficiently macerated before treating with acetic. I have secured my best results by using the following solutions: (*1*) 15 per cent alcohol—48 hours; (*2*) 1 per cent glacial acetic—24 hours; (*3*) 1 per cent osmic—12 minutes; (*4*) 12 per cent ammonia (stock considered 100 per cent)—10 minutes. It is very necessary to dissect away any connective tissue binding the muscles together. The osmic solution should be squirted between the muscles with a fine pipette. After washing overnight in running water the preparations are cleared in glycerine. Cleared specimens show at a glance the complete innervation (exclusive of endings). The fine intra-muscular nerves are generally so numerous that it has been found confusing to attempt tracing out the nerves without first dissecting free some of the more superficial muscles. All observations stated below have been checked up from several preparations. It cannot be claimed that every preparation will show a complete innervation. The main branches are uniformly stained but, unless the material is sufficiently macerated, all of the terminal twigs will not be stained.

In both urodeles and Salientia, we have found a great uniformity in the musculature, especially as regards the number and relative position of the elements. Such is not the case as regards the innervation. The nerves do not always have a constant relation to the other nerves. The number of branches to a muscle is variable. This was recognized long ago. Gadow (1882) recognized that homologous muscles, even in closely related species, may occasionally have a different innervation. Adolphi (1893, 1895, 1898) showed that there is great variation in the pelvic plexus of certain Salientia. I have found considerable variation in the relative position of the nerves. For example, in a specimen of *Acris gryllus*, the nerves on the left side which supply the gemellus arise as shown in Plate XIX, fig. 2, while on the right side of the same specimen they arise from practically the same point on the ischiadic stem as the nerve to the obturator internus. Another case: the branch to the tensor fasciæ latæ in one of four specimens of *Acris gryllus*, collected at the same locality, arises from the nerve to the iliacus internus; in the other three specimens, this branch comes off the branch common to the iliacus externus and internus. Although a muscle in a series of genera may have a constant relation to the surrounding muscles, the nerve which innervates it may have a variable relation to the surrounding nerves. In both *Pipa pipa* and *Xenopus mülleri*, the branch to the iliofibularis and the one to the iliofemoralis do not arise from the main peroneal nerve, as

in *Acris*, *Hyla*, *Rana*, etc., but arise from the ramus profundus anterior. Although *Pipa* and *Xenopus* are unquestionably closely related, there is a great difference in the number and position of the branches innervating their semimembranosus and the semitendinosus respectively. It has been sometimes assumed that if two muscles are innervated by two nerves arising from the same point on a main branch, the two muscles must have arisen from a single mass. Obviously, this cannot always be true in cases where the innervation is so variable as we find it in both urodeles and Salientia. Still, throughout the series of frogs and toads examined, certain nerves were found to be more or less constantly associated. These associations are interesting in that they afford us a basis of homologizing not always the nerve branches themselves, for they are sometimes too variable, but the muscles which they in general supply. The following groups may be distinguished in all Salientia.

Group I. *Iliacus externus and internus.*

The nerves supplying these two muscles arise from nearly the same point on the cruralis trunk.

Group II. *Pectineus and Adductor longus.*

The branch innervating the adductor longus (if present) is always more closely associated with the nerves to the pectineus than with any other.

Group III. *Tensor fasciæ latæ.*

The nerve supplying the tensor fasciæ latæ may arise from the cruralis or from one of its branches. It is generally more closely associated with one of the branches supplying the iliacus externus than with any other crural nerve.

Group IV. *Obturator internus and Gemellus.*

The nerves to these muscles may arise from a single stem or they may arise from different portions of the ischiadic. The extreme separation is shown in *Acris*.

Group V. *Quadratus femoris, Obturator externus and Adductor magnus.*

In all Salientia examined, the nerves supplying these muscles arise from a single stem. The nerves to the quadratus femoris and obturator externus are closely associated but the nerves to the dorsal and ventral head of the adductor magnus vary greatly in relative position according to the genus.

Group VI. *Semimembranosus, Semitendinosus, Gracilis major and minor.*

The main nerves to these muscles arise from a common stem. The semimembranosus in *Acris* and *Hyla* receives a branch from the ramus

profundus posterior of the ischiadic. The number and relative position of the branches supplying the muscles of this group are extremely variable.

Group VIII. *Cruralis and Glutæus.*

The ramus profundus anterior alone supplies the glutæus and cruralis.

Group VIII. *Iliofibularis.*

The nerve to this muscle has a variable position as regards the other peroneal nerves.

Group IX. *Iliofemoralis.*

The nerve to the iliofemoralis cannot be grouped with any of the other nerves because of its variable position in relation to other peroneal and ischiadic nerves.

Group X. *Pyriformis.*

The nerve to the pyriformis (if present) is always distinctly separated from the other nerves. In *Ascaphus*, the nerve to the caudalipuboischiotibialis arises as a branch from this nerve.

It would be less difficult to homologize the thigh muscles of the Salientia with those of the urodele if we could recognize in the salamander nerve groups homologous to the above. It is quite useless to attempt to homologize any but these larger categories of nerves. Although we have found great uniformity in the thigh musculature of the urodeles, the nerves show no such regularity. This will at once be obvious by a comparison of DeMan's (1873, Plate II, fig. 4) figure of the main nerve trunks in the thigh of *Triturus cristatus* with my figure (Plate XX, fig. 1) of the same in *Desmognathus*. Further, I find considerable differences in the thigh nerves of two such closely related forms as *Eurycea bislineata* and *Desmognathus fuscus*, especially as regards the innervation of the puboischiofemoralis externus. These differences lie chiefly in the number and relations of the branches. In *Rhyacotriton*, the obturator nerve supplies the puboischiotibialis. I have not been able to find any twigs of the obturator extending into the puboischiotibialis of either *Desmognathus* or *Eurycea*. It seems that the more primitive condition is that found in *Rhyacotriton* and the loss in the plethodontids is very suggestive of how the Pro-Salientia may have commenced a reduction of the obturator innervation.

The iliotibialis of *Rhyacotriton* is supplied not only by the femoral innervation of the plethodontids but also by a small twig from the peroneal nerve to the iliofemoralis. The question immediately arises

whether this double innervation is a primitive condition, or whether it is a specialized one. The fact that the twig supplies such a small fraction of the whole muscle makes it seem very probable that this double innervation is a specialized condition having arisen by the fusion of some of the fibres of the iliofemoralis, together with their nerve, to the iliotibialis.

The iliofemoralis (that portion of the puboischiofemoralis internus mass arising on the outer face of the ilium or wrapping around it posteriorly) possesses in the several salamanders I have examined only a peroneal or better a peroneal-ischiadic innervation, since the more proximal branch arises from the common peroneal-ischiadic stem. In the reptiles, the iliofemoralis is partly (in some forms wholly) innervated by a crural nerve. The Salientia retain a peroneal innervation similar to the salamanders. There can be no doubt that the iliofemoralis of the Salientia is homologous, at least in part, to the iliofemoralis of the urodeles.

The chief difficulty in attempting to homologize the main nerve branches, or nerve groups, of the salamander with those of the frog lies in the fact that there is no obturator nerve in the latter. The pelvis of the Salientia was recognized long ago as a very specialized structure and DeMan (1873) assumed that the obturator nerve, together with its foramen, was squeezed out of the pelvis by the approximation of the two halves of that structure in evolution from a more salamander-like prototype. Such is probably the correct view, but this loss is not a very great one. In certain plethodontids where there is no compression of the pelvis, the obturator nerve has already begun to dwindle. It does not reach the puboischiotibialis, and the puboischiofemoralis externus is chiefly supplied by the ischiadic. DeMan assumed a migration of obturator fibres around the ilium took place in the change from the salamander to the frog type. But the obturator supply is such an insignificant one in the more specialized urodeles that the assumption of a complete loss without any migration of fibres seems to me to be the most reasonable one.

In previous accounts of the nerve supply to the thigh muscles of salamanders, the same omissions have been made that we find in the accounts of the thigh muscles. It has not been recognized that the nerves which supply the adductor femoris are very distinct from the nerves which supply the pubotibialis and the puboischiofemoralis externus. This I have indicated in a drawing of the nerves, both inter- and intra-muscular, supplying the ventral thigh muscles of *Desmog-*

nathus (Plate XXI, fig. 1). In figure 3 (same plate), I have represented the complete innervation of the pubotibialis of the same species. It is clear that none of the nerves to the pubotibialis receive or send twigs to the adductor femoris. This evidence supports the view expressed above that the adductor femoris is a very distinct muscle, perhaps not at all closely related genetically to the pubotibialis.

The second innervation which has not been clearly defined is that to the iliotibialis. It has been recognized that the anterior part of the "iliotibialis" (DeMan) received a crural supply, but it has not been pointed out that the iliotibialis and the ilio-extensorius, confused together under the name "iliotibialis," have a totally different innervation. I have pointed out that in *Rhyacotriton* a small twig of the nerve to the iliofemoralis extends to the iliotibialis but this condition, which I have suggested above as secondary, does not mar the distinctness of the innervation of the iliotibialis and ilio-extensorius. In Plate XXI, fig. 2, I have represented the complete innervation of the three dorsal muscles, iliotibialis, ilio-extensorius, and iliofibularis, of *Desmognathus*. This innervation I consider typical of the urodeles. The first muscle receives a crural, while the two latter a peroneal innervation. It will appear that the nerves to these two latter muscles are very closely associated, suggesting that the muscles may be more or less related genetically. I have, in Plate XX, fig. 1, indicated the main nerve trunks in *Desmognathus*. A comparison of the figure with that of the main nerves in *Acris* (Plate XX, fig. 2) will make it clear that several of the nerve groups found in the Salientia may also be found in the urodeles. We may consider these apparent homologies under the group headings we have applied to the Salientia.

Group I, Group II, and Group III are certainly represented in the femoral nerves of the urodeles. The obturator nerve has already been discussed. It apparently dropped out in phylogeny. Group II of the Salientia is apparently more closely related to Group I than to Group III. This allows us, so far as relative position is concerned, to homologize Group III, or the nerve to the tensor fasciæ latæ, with the nerves to the iliotibialis of the salamander.

It becomes much more difficult to distinguish any other groups in the urodele innervation, but, judging from position and mutual relations, it would seem that the following homologies might be suggested:

Group IV,	Salientia	Ischiofemoralis, urodele
Group VII,	"	Ilio-extensorius, "
Group VIII,	"	Iliofibularis, "
Group IX,	"	Iliofemoralis, "
Group X,	"	Caudalifemoralis (+Caudalipuboischiotibialis), urodele

These homologies become very apparent when the muscles innervated by these nerves are considered at the same time. In fact, the nerves cannot be homologized with any assurance unless the muscles are considered at the same time; nor can the muscles be homologized without the evidence derived from the innervation. Both muscles and nerves are mutually, although neither wholly, dependent on the other for support in determining these homologies.

Comparison of Muscles

It has already been mentioned that the thigh muscles of the primitive Salientia (such as *Ascaphus*) are not very different from those of the more generalized salamander. This will be clear by comparing the outline figures (Plate XVII, figs. 4 and 5) of the thigh muscles of *Ascaphus* with a figure of the muscles of a salamander such as *Rhyacotriton* (Plate XVII, figs. 2 and 3). In order to facilitate this comparison, I have indicated salamander names on homologous muscles in *Ascaphus*.

There can be little doubt that the puboischiofemoralis internus of the salamander has broken up in the frog into the pectineus ventrally and the two (primitively three) iliacus muscles dorsally. I have suggested these changes in a series of schematic drawings (Plate XXIII). The drawings may be taken as representing ideal cross-sections of the thigh at a point near the acetabulum. It will be noted that the innervation permits of no other interpretation, unless it be in regard to the tensor fasciæ latæ. This is primitively a well-developed muscle in the Salientia and I have homologized it directly with the iliotibialis which, as we have seen above, is a very distinct muscle, although one often confused with the ilio-extensorius.

Again referring to our figures and to the diagrams, it will appear that the generalized salientian and urodele have almost exactly the same number of elements on the ventral surface of the thigh and that these are similarly placed. In *Ascaphus*, the so-called ventral head of the adductor magnus (actually a distinct muscles as origin, insertion, and innervation show) possesses a tendinous proximal head and overlies the powerful obturator externus precisely as the pubotibialis overlies the adductor femoris in the same relative position in *Rhyacotriton*. The innervation, too, supports the view that the adductor magnus, caput ventrale is homologous to the pubotibialis, the obturator externus to the adductor femoris. In the Salientia, immediately adjacent to the obturator externus, there is a small muscle which the innervation shows to be closely allied to the obturator externus. This, the quadrator femoris,

may have recently split off from the latter. At least, it probably finds its homologue in a small part of the adductor femoris.

A glance at the ventral surface of the thigh of *Ascaphus* and that of any salamander will make another comparison obvious. The puboischiotibialis of the salamander has precisely the same relations as the sartorio-semitendinosus of the primitive Salientia. The origin and insertion, as may be seen from the figures, are the same. The presence of an obturator innervation in some salamanders has already been mentioned as having little significance. In the schematized drawings (Plate XXIII) I have suggested how this obturator innervation probably gradually disappeared.

In *Ascaphus*, but more particularly in the pipids and pelobatids, the adductor magnus, caput dorsale retains its primitive position and independence. It is apparent that this head, actually a distinct muscle, must be homologous to the puboischiofemoralis externus of the salamander. It has the same relative position and, further, its innervation except for the obturator nerve is the same.

There can be little doubt about the homologies of the three remaining ventral (or posterior) muscles. In *Ascaphus*, the two coccygeal muscles mark these off from the dorsal muscles. The origin, innervation, and insertion demonstrate that the coccygeal muscles of *Ascaphus* are homologous to the caudalifemoralis and caudalipuboischiotibialis, respectively, of the salamander. The semimembranosus and gracilis major and minor must be represented in the ischioflexorius of the salamander, for that muscle lies between the extrinsic tail muscles and the puboischiotibialis of the urodeles. The latter muscles are carried over to the frog in such an unmodified form that their homologies are readily recognizable. Further, the innervation supports the view that the semimembranosus and gracilis major and minor are represented in the ischioflexorius of the salamander. In *Ascaphus*, we find the posterior coccygeal muscle (of each side) attaching to the inscriptio tendinea of the semimembranosus exactly as the caudalipuboischiotibialis attaches in part to the ischioflexorius of salamanders.

It will be seen from the diagrams (Plate XXIII) and the figures of the muscle origins in *Rhyacotriton* (Plate XXII, fig. 1) and *Ascaphus* (Plate XXII, fig. 3) that the obturator internus and gemellus of the frog must have become greatly modified to have evolved from the ischiofemoralis of salamanders. Nevertheless, the innervation, as we have seen above, seems to indicate that this is what has taken place, and there is no damaging evidence to be derived from origins, insertions, or relative position of these muscles.

N. Peroneus	(Femoralis o Vastus lateralis Vastus medialis Vastus intermedius	Femorotibialis (femoral only)	Absent	Absent	*totriton*, etc.), the anterior part of ilio-extensorius tendinous forming an incipient head homologous to the cruralis
N. Peroneus	Tensor fasciæ latæ (femoral only) Glutæus medius " minimus " profundus " ventralis (Femoralis) " maximus	Iliofemoralis (+Femoral)	Iliofemoralis	Iliofemoralis	Name iliofemoralis of salamander restricted to that portion of the puboischiofemoralis internus mass arising on outer surface of ilium. It is innervated by two branches from the peroneal only
N. Peroneus	Biceps	Iliofibularis	Iliofibularis	Iliofibularis	

TABLE 1.—THE HOMOLOGIES OF THE THIGH MUSCLES

		PLACENTAL	SPHENODON	SALAMANDER	FROG	REMARKS
Plexus Crualis	*N. Femoralis*	Psoas major Iliacus Pectineus	Puboischiofemoralis internus	Puboischiofemoralis internus	Dorsal = Iliacus externus + Iliacus internus Ventral = Pectineus ↘ Adductor longus	Adductor longus not differentiated from pectineus in more primitive frogs (and certain higher genera)
		Sartorius	Ambiens	Iliotibialis (+small twig from nerve to iliofemoralis (Peroneus) in *Rhyacotriton*)	Tensor fasciæ latæ	Iliotibialis of salamander often confused with ilio-extensorius. Tensor fasciæ latæ of frog primitively a well-developed muscle, reduced in specialized forms
	N. Obturatorius	Obturator externus	Puboischiofemoralis externus	Puboischiofemoralis externus	Adductor magnus, caput dorsale	Adductor magnus of the frog composed primitively of two distinct muscles
		Quadratus femoris (ischiadic only)	(+ischiadic)	(mostly ischiadic)	(only ischiadic)	
		Adductor brevis Adductor longus Adductor magnus (+ischiadic in Man)	Adductor femoris (Ischiofemoralis of Gadow) (+ischiadic)	Adductor femoris (ischiadic only)	Obturator externus Quadratus femoris (ischiadic only)	Primitively a long muscle; in the frog similar in form and relations to the Adductor femoris of salamander
	N. Ischiadicus	Gracilis (obturator only)	Puboischiotibialis (obturator only; in lizard ischiadic and obturator)	Puboischiotibialis (+obturator in *Rhyacotriton*)	Semitendinosus ↘ Sartorius	The Semitendinosus of the most primitive frogs (i.e., *Ascaphus*) has almost identical origin and innervation as the puboischiotibialis of the salamander
		Absent	Pubotibialis (+obturator)	Pubotibialis	Adductor magnus, caput ventrale	
		Absent Semimembranosus Semitendinosus	Flexortibialis externus			Gracilis minor of frog a slip of the gracilis major attaching primitively to the skin
		Tenuissimus (common nerve with adductor magnus in Man)	Flexortibialis internus (+obturator)	Ischioflexorius	Semimembranosus Gracilis major ↘ Gracilis minor	
		Obturator internus Gemellus superior Gemellus inferior	Ischiotrochantericus	Ischiofemoralis	Gemellus Obturator internus	These two muscles of frog innervated either by the same or different nerves
		Pyriformis	Coccygeo-femoralis brevis	Caudalifemoralis	Pyriformis	Caudalipuboischiotibialis found among frogs only in *Ascaphus*. Has no relation to "tail"
		Cruro-coccygeus	Coccygeo-femoralis longus	Caudalipuboischiotibialis	Caudalipuboischiotibialis	
Plexus Sacralis	*N. Peroneus*	(Femoralis only) Rectus femoris	Iliotibialis (+femoral)	Ilio-extensorius	Cruralis Glutæus	In some salamanders (*Desmognathus*, *Tylototriton*, etc.), the anterior part of ilio-extensorius tendinous forming an incipient head homologous to the cruralis
		(Femoralis only) Vastus lateralis Vastus medialis Vastus intermedius	Femorotibialis (femoral only)	Absent	Absent	
		Tensor fasciæ latæ (femoral only) Glutæus medius " minimus " profundus " ventralis (Femoralis) " maximus	Iliofemoralis (+Femoral)	Iliofemoralis	Iliofemoralis	Name iliofemoralis of salamander restricted to that portion of the puboischiofemoralis internus mass arising on outer surface of ilium. It is innervated by two branches from the peroneal only
	N. Peroneus	Biceps	Iliofibularis	Iliofibularis	Iliofibularis	

Little difficulty is experienced in determining the homologies of the dorsal thigh muscles. The origin and insertion, but especially the innervation, show that the iliofibularis and iliofemoralis of the frog are homologous to the muscles of the same name in the salamander. It is also apparent from the innervation that the glutæus and cruralis are simply two heads of a single muscle undoubtedly homologous to the ilio-extensorius of the salamander. I have represented in Plate XXIII the changes which this region probably underwent in changing from the salamander to the frog type.

Summary

The following table gives a summary of the homologies of the thigh muscles of the Salientia and the Caudata, as I see them, together with some supplementary remarks. I have added a list of what appears to be the homologous muscles in a reptile and a mammal. It will be obvious that most of the mammalian names applied to the frog are misnomers, in that the frog muscles are in practically all cases not at all homologous to the mammalian muscles of the same name. I have accepted Gadow (1882) for these reptilian and mammalian homologies, except where these homologies have been corrected by Mr. A. S. Romer, whose unpublished manuscript has been available to me. There is no doubt that the Salientia are specialized creatures, far removed from the main line of mammalian evolution. Still, the Pro-Salientia were probably not unlike the Caudata in regard to their pelvic musculature. The mammalian muscles have been traced with a fair degree of accuracy down to their beginnings in the urodeles. By homologizing these muscles in the urodeles with those in the salientians we have a basis of comparison between mammal and frog. I may add that it is only this extended systematic method which can give a sound basis to the determining of homologies.

OUTLINE OF SALIENTIAN PHYLOGENY

Adaptation and Phylogeny

It was recognized long ago by Günther that the dilation of the sacral diapophyses has little adaptive significance. Mivart (1869*a*) and since then several others have pointed out that arboreal, terrestrial, fossorial, or aquatic forms may possess dilated sacral diapophyses or they may possess cylindrical ones. It surely cannot be said that the dilated sacral diapophyses are adapted to any one type of locomotion. Similarly, it was pointed out by Günther and later by Mivart that the presence or absence of teeth are hardly correlated with the food habits of the species. I have recently examined a great many stomachs of African frogs and have come to the conclusion that toothed forms of large size (*Rana occipitalis*, etc.) may seize vertebrates occasionally or even prey on them nearly exclusively (*Rana ornatissima*), while toothless forms (*Bufo*), regardless of size, never take vertebrate prey. The absence of teeth is a limiting factor; it is not an adaptation to a food habit, for these toothless forms prey upon a great variety of invertebrates, chiefly insects.

It is highly probable that not only the dilation of the sacral diapophyses and the loss of teeth but also the acquisition of bony growths on the mandible, similating teeth, and the fusion of the pectoral girdle in the midline have all taken place, if not regardless, at least independently, of the environment. Highly specialized frogs (*Cerathyla*, *Ceratobatrachus*) exist in regions of maximum abundance of amphibian life. Still, it cannot be said that they are highly adapted to their environment. Many features of these and other specialized genera can have no adaptive significance.

So many cases of muscular adaptation occur in the Mammalia that it would seem, *a priori*, that the specialization of the thigh musculature in the Salientia must have taken place in adaptation to various modes of life. Long-legged, arboreal frogs have narrow, often tendinous muscles. The sartorius of *Leptopelis*, an arboreal ranid, is tendinous distally, similar to that of some of the more arboreal species of *Hyla*. Other modifications of proportion and extent may be correlated with the degree of use to which the limb is subjected. But the degree of differentiation does not seem to be definitely correlated with any particular mode of life. Fossorial and terrestrial pelobatids have the same number of elements in the thigh; arboreal, fossorial, aquatic, and terrestrial bufonids exhibit no differences in the number of elements. We find the

more specialized discoglossids and pelobatids have independently developed an adductor longus, but just how great a part any specific functioning might have played it is impossible to say. Possibly the differentiation of this muscle is correlated with certain springing movements, but on this point we have no information. It would seem that the differentiation of the thigh musculature has progressed from the generalized condition exhibited by the discoglossids to the specialized condition found in the ranids. Aquatic life may be said to have called forth a maximum development of the muscles, but it has not fostered the development of special swimming muscles. Possibly function has played a part in the sinking of the tendon of the semitendinosus through the gracilis mass. We have seen that this took place independently in a number of different genera. Too little is known about the mode of life of these specialized forms to state what part function might have played in the specialization of the semitendinosus. Although function must have played some part in muscular differentiation, this action has been more general than specific. Adaptation has not obscured the main trend of phylogeny. The myology as well as the osteology of the Salientia gives definite evidence as to the natural groups of genera.

In the accompanying chart I have attempted to schematize the phylogeny of the Salientia as I understand it. The four primary categories defined above are made the basis of this phylogeny and a few of the numerous parallelisms occurring in each of these categories are indicated. It is apparent from the above discussion that the vertebral column was originally opisthocœlous and consisted of eight presacral vertebræ. From this condition the vertebral column seems to have evolved the procœlous and finally the diplasiocœlous type, while a fusion of the vertebræ occurred independently of these changes. In the Salientia, teeth were primitively confined to the upper jaw and from this condition forms, on one hand with no teeth on either jaw and on the other with pseudo-teeth (in one instance true teeth) on the lower jaw, were evolved. Other changes which have occurred in more than one series are the dilation of the sacral diapophyses, the fusion of the pectoral girdle in the midline, and the development of intercalary phalanges, the latter being sometimes accompanied by the development of claw-shaped terminal phalanges. For the sake of clearness, I have listed the more essential changes in the following columns. If this table is compared with the accompanying chart, the orthogenetic and often parallel modifications of the Salientia will be more readily understood.

If the end stages indicated on the chart actually represent the terminations of a series of orthogenetic changes, they most certainly do not form the ancestral stock from which other groups possessing more primitive features have been derived. For example, in the diagram I have represented *Scutiger*, *Ophryophryne*, and *Ælurophryne* as the terminal twigs of the anomocœlous branch and the end of a distinct line of specialization, which specialization, as we have seen above, may be muscular as well as osteological. Nevertheless, Boulenger (1919, p. 470), although he correctly regards these three genera as toothless pelobatids, prefers to believe that they "may be described as lowly forms approaching the Discoglossidæ and leading on one hand to the Cystignathidæ (through *Batrachopsis*, Blgr.), and on the other to the Bufonidæ."

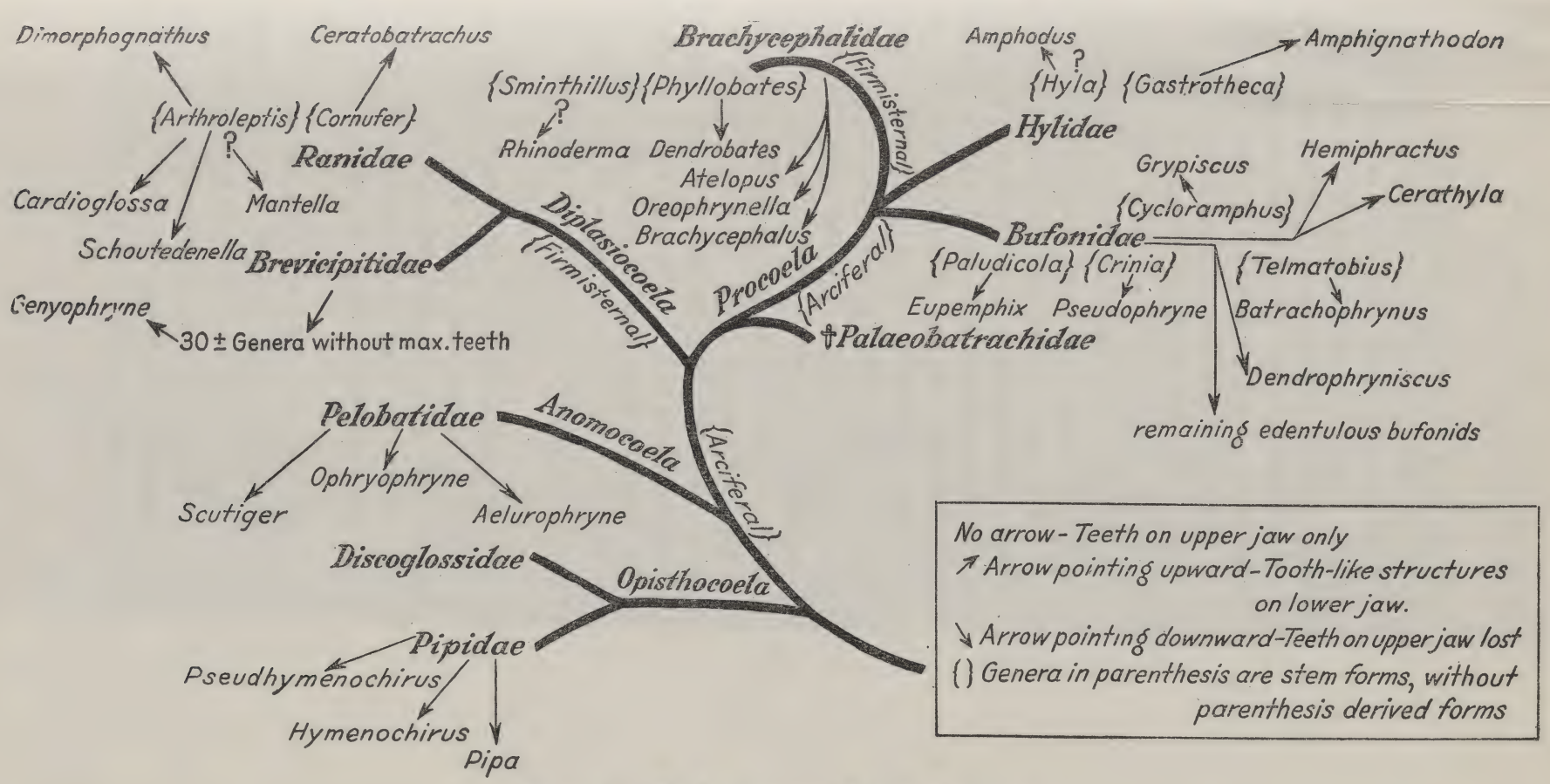
Such speculations might seem to receive some support from the ontogeny of frogs in general, since the tadpole, of course, possesses no true teeth. But we have seen above that in the adult only the specialized Salientia lack teeth. We have been able to trace out, with considerable detail, lines of specialization at the end stages of which the teeth were lost. Further, we have seen that the musculature of the thigh readily distinguishes the "Cystignathidæ" (=Bufonidæ, part) from the Discoglossidæ and Pelobatidæ. There is no evidence to believe that *Scutiger*, *Ophryophryne* and *Ælurophryne* are transitional genera in either their osteology or their myology.

The Salientia have not undergone innumerable and haphazard changes. Few possibilities of modification have seemed open to them. In nearly every family the same modifications crop out as if these were destined to appear as the family matured. There are, to be sure, certain modifications peculiar to certain families. As the anatomy of the Salientia becomes better known, other diagnostic characters will be brought out. The accompanying chart and table will, I believe, help to determine what characters may be expected to be fundamental.

Comparison of the Phylogeny of the Salientia with that of the Caudata

The thigh musculature of the frogs and toads has been compared with that of the urodeles. It may be well in closing to glance briefly at the phylogeny of the urodeles, for that apparently has been very different from the phylogeny of the Salientia. In the frogs and toads adaptation seems to have played a small part in the fundamental changes which have taken place, while in the Caudata adaptation seems to have been correlated with morphogenesis to a large extent.

Thigh Muscles	tinctly into two parts; obturator externus large; two pairs coccygeal muscles present. In specialized forms, adductor longus present; two heads of adductor magnus partly fused; only one pair of coccygeal muscles	semitendinosus. Parallels Procœla in loss of accessory head of iliacus externus in *Pelodytes*	ternus; partial fusion of two heads of adductor magnus; reduced condition of obturator externus. Specialized forms possess an accessory head of the adductor magnus and specialized gracilis minor	
Distal Tendons of Thigh	Primitively the tendon of the semitendinosus overlaps that of the gracilis major and minor; the tendon of the sartorius not developed. Specialization occurs in the pipids, the tendon of the semitendinosus becoming either partly enclosed within the gracilis (*Pipa*) or coming to underlie it (*Xenopus*) (see Pl. xvi)	The primitive condition of the discoglossids retained in this suborder. Specialization limited to the insertion of the gracilis minor (see *Scaphiopus* Pl. xi)	Typically the tendon of the semitendinosus overlaps that of the gracilis major and minor; the sartorius inserts on the tendon of the semitendinosus (Pl. xiv, fig. 2). Specialization limited to a sinking of the tendon of the semitendinosus into the gracilis mass or nearly completely through it; head of sartorius attaches to knee. Some modification from the typical condition in *Rhinophrynus* (Pl. xvi, fig. 6)	Differs consistently from Procœla in having the tendon of the semitendinosus always deep to that of the gracilis major and minor and never closely bound to it (Pl. xiv, fig. 3). Specialization limited to the development of secondary ligaments



Genetic Relations of the Salientia
with especial reference to dentition, vertebral column and pectoral girdle

TABLE 2.—PARALLEL MODIFICATIONS OF THE SALIENTIA

	OPISTHOCŒLA	ANOMOCŒLA	PROCŒLA	DIPLASIOCŒLA
DENTITION	Teeth primitively present on the maxillaries and vomers, completely lost in the end stages of specialization	Parallel modifications	Parallel modifications, but in the end stages, pseudo-teeth may develop on the mandible (in one genus true teeth)	Parallels the Procœla (but no true teeth ever present on mandible)
SACRAL VERTEBRA	Diapophyses of sacral vertebra primitively slightly dilated, becoming broadly expanded in specialized genera	Diapophyses typically dilated	Diapophyses primitively cylindrical, becoming greatly expanded in end stages of specialization	Parallels the Procœla
RIBS	Present at some period in the ontogeny	Absent	Absent	Absent
VERTEBRAL COLUMN	Primitively eight presacral vertebræ, reduced to five in end stages of specialization. Opisthocœlous	No reduction of vertebræ (except abnormally). Anomocœlous	Parallels Opisthocœla in fusion of vertebræ in the specialized brachycephalids. Procœlous	No reduction of vertebræ (except abnormally). Diplasiocœlous
PECTORAL GIRDLE	Primitively arciferal, becoming semi-firmisternal in the specialized pipids	Arciferal	Typically arciferal, becoming semi-firmisternal and firmisternal in the brachycephalids	Firmisternal
THIGH MUSCLES	Primitively no adductor longus; no sartorius; semitendinosus broad and superficial; iliacus externus broad or with accessory head; adductor magnus divided distinctly into two parts; obturator externus large; two pairs coccygeal muscles present. In specialized forms, adductor longus present; two heads of adductor magnus partly fused; only one pair of coccygeal muscles	Primitively similar to Opisthocœla but only one pair coccygeal muscles. Parallels Opisthocœla in development of adductor longus and reduction of the semitendinosus. Parallels Procœla in loss of accessory head of iliacus externus in *Pelodytes*	Differs in presence of adductor longus (typically) and sartorius; the deep position and narrow form of semitendinosus, loss of accessory head of iliacus externus; partial fusion of two heads of adductor magnus; reduced condition of obturator externus. Specialized forms possess an accessory head of the adductor magnus and specialized gracilis minor	Same as Procœla but adductor longus always present; also accessory head of adductor magnus. Parallels Procœla in expansion of the gracilis minor
DISTAL TENDONS OF THIGH	Primitively the tendon of the semitendinosus overlaps that of the gracilis major and minor; the tendon of the sartorius not developed. Specialization occurs in the pipids, the tendon of the semitendinosus becoming either partly enclosed within the gracilis (*Pipa*) or coming to underlie it (*Xenopus*) (see Pl. XVI)	The primitive condition of the discoglossids retained in this suborder. Specialization limited to the insertion of the gracilis minor (see *Scaphiopus* Pl. XI)	Typically the tendon of the semitendinosus overlaps that of the gracilis major and minor; the sartorius inserts on the tendon of the semitendinosus (Pl. XIV, fig. 2). Specialization limited to a sinking of the tendon of the semitendinosus into the gracilis mass or nearly completely through it; head of sartorius attaches to knee. Some modification from the typical condition in *Rhinophrynus* (Pl. XVI, fig. 6)	Differs consistently from Procœla in having the tendon of the semitendinosus always deep to that of the gracilis major and minor and never closely bound to it (Pl. XIV, fig. 3). Specialization limited to the development of secondary ligaments

It is now generally recognized that the most aquatic urodeles are not the most primitive, nor the most "larval," the most generalized. Terrestrial salamanders exhibiting the fewest losses of structure are believed to be more or less ancestral to the others. Some of these others are also terrestrial, but many are aquatic. A large number of the aquatic forms have failed to develop all the adult structures. These are recognized today as cases of arrested development, and the larval habitus of the forms is considered a secondary specialization.

The Necturidæ embraces only two genera, *Proteus* and *Necturus*. Both are "larval adults." The family habitus is therefore larval. The distinctive features of the family, the heritage by which its true relations may be determined, is greatly obscured by this habitus. It is only such obscure features as the absence of an ypsiloid apparatus, the presence of lungs, the presence of a distinctive auditory apparatus, and some features of the pelvis and skull which make it apparent that the Necturidæ represent a distinct line of evolution, their immediate ancestors not to be found in any of the existing Caudata.

The Sirenidæ, like the Necturidæ, are of uncertain origin. Their whole structure has been modified for an aquatic and burrowing life. In no family of Salientia except the Pipidæ are all the members highly adapted to one particular mode of life.

Another aquatic family is the Cryptobranchidæ. *Cryptobranchus* is more "larval" than *Megalobatrachus*, but both have a very similar habitus. It is very probable that the immediate ancestors of the Cryptobranchidæ will be found in less aquatic hynobiids. Without considering the structure of either group, it may be said that the more superficial changes which the Cryptobranchidæ have undergone seem to adapt them to an aquatic existence.

The most splendid cases of adaptation occur in the higher Caudata. Wilder and Dunn (1920) have suggested that the Plethodontidæ evolved in a mountain brook habitat, and that the loss of the lungs in this family is correlated with such an origin. Today, plethodontids are found in a variety of habitats but they all retain their heritage of lunglessness.

Recently Reed (1920) has reviewed the morphology of the auditory apparatus in the urodeles. He has found that practically every family is distinguished by a definite type of apparatus which is, as might be expected, highly adapted to the needs of the respective groups. In the Salientia, the auditory apparatus undergoes remarkable changes within a single family. It is, to be sure, more or less adapted to the definite

needs of the animal, but the genera in each family have such a diversity of habits that the auditory apparatus does not possess a distinctive form in any one of the larger groups.

The Caudata do not exhibit numerous parallelisms in their phylogeny, such as we have seen in the Salientia. The Plethodontidæ, for example, have specialized along a line of their own. They have undoubtedly arisen from the more generalized salamandrids and many of their distinctive features may be considered losses. The loss of the pterygoid and ypsiloid apparatus may be taken as an example.

The amphiumids may also have arisen from the salamandrids. Their loss of ypsiloid apparatus and reduction of the limbs seems to be an adaptation to their semi-fossorial and aquatic life. The ambystomids are in many ways more generalized than the salamandrids. They may have given rise to the latter family. It is important to note that each family has a more or less definite habitus characterized in general by adaptations to a particular life. In the Salientia, but few of these restrictions occur. The families are not so circumscribed by particular adaptations. The habitus of the families of Salientia is too varied to be distinctive, while it is otherwise with most Caudata. In the urodeles, adaptations seems to have played a considerable rôle in the morphogenesis of the families; in the Salientia, this rôle seems to have been reduced to a minimum.

Characters which define genera and species of Salientia are of a very different kind from those which define the families. In the first place, they are often highly adaptative. Differences in the extent of webbing between the digits, in the development of metatarsal tubercles, in the position of the digits, and in the ossification of parts of the pectoral girdle seem to have an adaptive significance. Not all of the characters which define the genera are obviously adaptive. Differences in the form and extent of the vomerine teeth, in the exact form of the pupil, in the loss of elements from the pectoral girdle, etc., are either not at all adaptive or only slightly so. In general, it may be said that, in the Salientia, the characters defining the species are more adaptive than those defining the genera, those distinguishing the genera more adaptive than those diagnostic of families, while the few characters we have found to define the suborders are the least correlated with function or habit.

ORIGIN OF THE SALIENTIAN FAUNÆ

General Statement

If the genetic relationships of the frogs and toads as outlined above have been correctly interpreted, many difficulties of distribution are at once removed. To take but a single example, Hewitt (1911, p. 36) was at a loss to account for the occurrence of "dendrobatids" in Madagascar, tropical Africa, and tropical America. Arldt (1917, p. 134) boldly revives the phantom land bridge which has been thrown so many times across the Atlantic. The real explanation, however, is simple. *Cardioglossa* in Africa has arisen from the *variabilis* group of *Arthroleptis* by a loss of the maxillary teeth, while *Dendrobates*, in tropical America, has arisen directly from *Phyllobates* by a similar modification. *Mantella* in Madagascar has arisen from a Madagascan ranid, very probably *Arthroleptis*, and has no relation to *Dendrobates*, which, as we have seen above, has evolved from the bufonids.

If the recent herpetological literature is critically examined, it will appear that today there is no need for the antarctic continents or mid-Atlantic land bridges which have been revived from time to time to account for the distribution of the Salientia. Perhaps the most recent of these revivals is that of Metcalf (1921*a*) who has brought some additional evidence derived from a study of the opalinid parasites of the Salientia. There seems to me to be little need for the land bridges Metcalf has revived. Hylids and "leptodactylids" occur in the Ethiopian region. We have merged the "leptodactylids" into the Bufonidæ, while the hylids have almost certainly evolved from this bufonid stock. The pipids now include four genera: *Pipa*, *Xenopus*, *Hymenochirus* and *Pseudhymenochirus*. This explanation of a former wide dispersal and present restriction of range is much simpler than the assumption of a mid-Atlantic land bridge. A land bridge admits a flood of forms. Witness the numerous forms which have certainly migrated in comparatively recent times across the Isthmus of Panama. The fauna of Africa is essentially unlike that of South America. The few resemblances between the two faunæ are not to be accounted for by assuming a land bridge between the continents.

It is well known that the fossil record gives us little aid in determining the past history of the Salientia. We have barely mentioned the fossil evidence in discussing the phylogeny, for this evidence neither supports nor refutes the conclusions reached. None of the fossils may be considered more annectant than forms living today. In fact, the majority

of these forms are referred to living genera. Nor does the fossil record suggest early centers of dispersal, widely removed from present ranges. In determining the origin of the salientian faunæ, we have had to rely on the genetic relations of the groups and their present geographical positions.

Several of the families of Salientia were probably differentiated as early as the Jurassic. The oldest known frog has been referred to the genus *Palæobatrachus* by Vidal. It comes from the Kimmeridge beds of Spain. Of almost equal antiquity are the fragments of a skeleton described as *Eobatrachus agilis*. These were secured in Quarry 9 of the Como Bluff, Wyoming. They have recently been redescribed (Moodie, 1912, 1914) and apparently represent two individuals: "one specimen, a lower end of a left humerus, somewhat smaller than the type; the other or type humerus; the lower end of a tibio-fibula; the entire left (?) femur; the entire right ilium; all, apparently of a single individual excepting the humerus first referred to, which indicated a second frog though possibly of the same species." Moodie was unable to distinguish these bones from similar ones in modern Salientia. In fact, he goes so far as to place *Eobatrachus agilis* in the Bufonidæ, "and possibly even in the genus *Bufo*." This, of course, is merely a guess, as no family characters have yet been distinguished in the elements under discussion. Still, the evidence is sufficient to demonstrate that the families of modern Salientia were at least in part defined as early as the Jurassic. It is no wonder, then, that certain families of modern Salientia exhibit today a discontinuous distribution.

African Fauna

Twenty-nine of the thirty-nine genera of frogs and toads found in Africa are peculiar to that continent. Four of the ten exceptions have their headquarters in Africa, three (*Arthroleptis*, *Hyperolius*, and *Megalixalus*) of these having extended their range to Madagascar, and the fourth (*Phrynomantis*) having a representative, probably not at all congeneric with it, on two islands of the East Indies. Three other non-indigenous genera (*Rana*, *Bufo*, and *Discoglossus*) have apparently migrated into Africa in comparatively recent times and by way of the northeast or northwest. Two others (*Nectophryne* and *Pseudophryne*) are representatives of an ancient and highly modified group which may or may not have gained access to Africa from the northeast. The last genus (*Hyla*) represents a complex problem, two races of one species having barely reached Africa on the north, while the only other represen-

tative of the genus, although restricted in range to Abyssinia, seems to have its nearest affinities in certain South American species.

The record of a *Hyla* from Abyssinia has received little or no comment in the literature. Nieden (1911) described it as *H. wachei* and gives Dire Daua as its type locality. Although Nieden pointed out that this species was the first *Hyla* recorded from the Ethiopian region, he did not discuss its relationships. One would imagine from the consideration of the distribution of African reptiles that the species would show close affinities to *Hyla arborea savignyi* of Syria and Palestine. Such is not the case. It has very little in common with any Asiatic *Hyla* and but little more with any Australian or East Indian species. It agrees entirely with the *maxima* group of species from northern South America. In fact, only one point of difference appears in the original description to distinguish *H. wachei* from *H. maxima* as represented by a large series before me from British Guiana and Colombia. Nieden gives the web of the fourth toe of *H. wachei* reaching only to the end of the antepenultimate phalanx, while in *H. maxima* it reaches to the end of the penultimate. It is very possible that the peculiar arrangement of the vomerine teeth, characteristic of the *maxima* group, could have had a parallel evolution in two such widely separated areas as Abyssinia and South America. The species of "*Hylella*" and *Nyctimantis* have very probably evolved independently in the East Indies and South American regions by a parallel modification of the *Hyla* stock. *H. wachei* is known only from the type. If this specimen actually came from Abyssinia, and we have no reason to doubt it, the genus *Hyla* must have existed in Africa for a very long time, since *H. wachei* shows no close affinity to the eastern representatives of the genus.

Perhaps more remarkable from the standpoint of zoögeography than the discovery of a *Hyla* of South American affinities in Abyssinia was the recent find of a "leptodactylid" in South Africa. This genus, *Heleophryne*, is very distinct but it seems to be more closely related to certain Australian-New Guinean genera than to any of the South American. Still, it agrees with *Centrolene* and *Centrolenella* of Ecuador and Colombia in lacking the omosternum and in possessing moderately dilated sacral diapophyses and T-shaped terminal phalanges. *Heleophryne* differs from both *Centrolene* and *Centrolenella* in several features. It lacks the intercalated phalanx and the web between the fingers. It possesses a vertical pupil and well-developed series of vomerine teeth.

Heleophryne is apparently most closely related to the *Limnodynastes-Ranaster* group of genera. The numerous differences which distin-

guish it from these genera seem to me to be of secondary importance. It is possible that the dilation of the sacral diapophyses and reduction of the omosternum have arisen independently in these Australian, African, and South American genera under discussion. In that event, the true relationships of *Heleophryne* have been obscured through convergence.

The Ranidæ and Brevicipitidæ very probably have been in Africa since Eocene times and both may have come in from the north. Madagascar has been a center of differentiation for "dyscophids" but the two genera in Africa suggest that the toothed brevicipitids may have gained access to Madagascar from the nearby continent. No serious difficulties are met with in assuming a center of dispersal for the brevicipitids in southern Asia and a subsequent migration on one hand to the Malay Archipelago, the East Indies, and especially to New Guinea,[1] and, on the other hand, an early migration to Africa at a time when Madagascar, if not connected with Africa, at least was not beyond the reach of the African stock which, upon reaching Madagascar,[2] formed a line of specialization parallelling to a large extent the East Indian series.

The ranids must have reached Africa at an early time. Their center of generic differentiation is the Cameroon-Gaboon area. If the distribution of forest and open country was then very much as it is now, we would expect that the Cameroon mountains might afford just such a region fostering specialization. Forests alone apparently do not contain all the requisites for the maximum possibilities of amphibian life. Compare,[3] for instance, the amphibian fauna of the Organ Mountains with that of the surrounding Brazilian forests, or the peculiar genera of the Ecuadorian montaña with that of the Amazonian forests lying to the east. Geographical evidence has recently been brought forward to support the view that the Congo basin has been inundated for some time. Such a condition would also account for the obvious fact that the forest fauna of the Upper Congo is a derived one, composed of either wide-ranging forest forms or migrants from the Cameroon-Gaboon area. In brief we may assume that the Cameroon-Gaboon area has been a center of differentiation either because of its diverse topography or because it has not suffered the drowning process of the Congo Basin. Both factors may have played a part.

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[1]Van Kampen (1919, p. 54) recognizes 13 genera and 35 species of brevicipitids in New Guinea lacking teeth in the upper jaw.

[2]Boettger (1913) recognized 9 genera of the more primitive brevicipitids possessing the maxillary teeth and 4 genera lacking them.

[3]Baumann (1912).

It should be emphasized that, while the Brevicipitidæ and Ranidæ have almost certainly gained access to Africa from the north, the same may be said for the Bufonidæ. If we assume a similar polar origin for the Pipidæ, Hylidæ, and "Leptodactylidæ," we escape the necessity of building any land bridge. If we assume a single land bridge, one from South Africa to Australia, we have to explain why only such a limited representation of such diverse stocks was able to cross to Africa. The same may be said for a land bridge across the Atlantic.

Hewitt (1911) and many earlier workers have insisted that there is good geological proof of the former existence of these land bridges. With this opinion I cannot agree. Many of the statements made by Hewitt (1911) are contrary to fact. Hewitt's paper is apparently the most comprehensive account of the distribution of African amphibians published in recent years, but his opinions are based on the conclusions of others. If his evidence is re-examined from the different point of view emphasized above, the necessity for much of this bridge building will be eliminated. I agree entirely, however, with his final conclusions (1911, p. 39) as to his land bridge hypothesis:

> . . . it must be admitted that the kind of evidence that is required to properly establish these hypotheses is altogether lacking, in the almost complete absence of fossil forms: nor do we possess the whole evidence of comparative anatomy, for our judgements of generic relationships are based upon the more easily ascertained and superficial characters, and the data for a genetic arrangement of the genera are still wanting.

I have attempted in the first part of this paper to indicate the broad features of these genetic relations. We are justified, I believe, in assuming that the entire amphibian fauna of Africa, either directly or indirectly, gained access to Africa from the north.

Neotropical Fauna

The continent of South America, probably because of its diverse topography, supports a rich salientian fauna. Only thirty-nine genera of frogs and toads occur in Africa, while in South America there are no less than sixty. The exact number will, of course, vary according to whether or not one recognizes such unnatural assemblages as *Hyella*. In the present instance I have included only natural groups. Fortunately, I have had at one time or another the opportunity of examining the majority—forty-six—of these genera.

Twenty-one of the sixty genera occur also in Central America, but only two of these, aside from the nearly cosmopolitan *Rana*, *Bufo*, and

Hyla, occur outside the neotropics. These two, *Hypopachus* and *Gastrophryne*, are brevicipitids found today in southern United States. Their distribution suggests the route by which the Brevicipitidæ probably reached South America. The Brevicipitidæ may be the oldest firmisternal family on that continent. At least it includes the most specialized forms. We have suggested above that all toothless brevicipitids arose directly or indirectly from forms possessing maxillary teeth. It is not probable that any of the South American brevicipitids have been recently evolved from toothed forms. It is more probable that they have all arisen from some *Hypopachus*-like ancestor which gained access to South America at comparatively early times. Today, eight genera of brevicipitids are known to occur in South America. They are *Hypopachus*, *Stereocyclops*, *Gastrophryne*, *Ctenophryne*, *Chiasmocleis*, *Glossostoma*, *Dermatonotus* and *Otophryne*.

There is a second firmisternal stock in South America which, unlike the Brevicipitidæ, must have reached the continent at very recent times, certainly since the Panama connection, and very probably by way of the north. This is *Rana*, the sole representative of that typically Ethiopian family, the Ranidæ. Most text books cite several genera of ranids as occurring in South America. But in a recent revision I have shown[1] that *Prostherapis* and *Phyllodromus* should be referred to *Phyllobates*, while *Colostethus* should be deleted from the system. We have seen above that *Phyllobates* is a typical brachycephalid, much more closely related to the bufonids than to the ranids. This leaves *Rana* with one or more, probably two, species to represent the great family of Ranidæ in South America. Several other species of *Rana* occur in Central America. The restricted range of the genus in northern South America is further proof of its having only recently gained a foothold upon that continent.

The third family of firmisternal forms in South America I have defined above as the Brachycephalidæ. Their procœlous vertebral column, their bufonid type of distal tendons in the thigh, and, lastly, their occasionally incomplete firmisternal girdle, all point towards their independent origin from the bufonids. Future work may show that they have had a polyphyletic origin. It seems probable that *Sminthillus* has acquired its semi-firmisternal girdle independently of the other genera. All brachycephalids very probably evolved from the Bufonidæ and from that family alone. In recognizing this fact, I believe we have made a distinct advance, whether or not we divide the Brachycephalidæ

[1]Barbour and Noble (1920, p. 398).

into subfamilies or into groups of genera having a close affinity. It is not difficult to divide the family into groups of related genera. At the present time, ten genera are referable to the family. I have dissected all except one (*Chilixalus*) of these, but one other (*Oreophrynella*) has been studied only in part. These ten genera are: *Brachycephalus*, *Atelopus*, *Rhinoderma*, *Sminthillus*, *Geobatrachus*, *Oreophrynella*, *Phyllobates*, *Hyloxalus*, *Chilixalus* and *Dendrobates*. Four of the ten genera are found in neotropical regions beyond the limits of South America. Three of these may have migrated into Central America since the Panama connection, but one (*Sminthillus*) may have arisen, at least in part, in Cuba. It is very probable that all brachycephalids (except *Sminthillus*, in part) have arisen in South America from bufonid genera existing there.

Under the present system of classification, I recognize nine genera of Hylidæ as occurring in South America. This includes *Amphignathodon*, which we have seen above is merely a specialized *Gastrotheca*. Five of the nine genera occur in Central America, which may boast of two genera of hylids peculiar to it. Still, these two genera are not strikingly different from *Hyla*.

The genus *Hyla* possesses nearly a world-wide distribution, except for a great gap in the Indo-Oriental region. Formerly considerable emphasis was placed on this gap in its present distribution. This, together with the abundance of the genus in the South American and Australian regions, seemed to lend some support to the Gondwana land hypothesis. But today we know of one true *Hyla* from the Ethiopian region and three toothed bufonids. The latter are all referable to the single genus *Heleophryne*. It thus seems most likely that the genus *Hyla* originated in the north and pushed southward into Africa and the Oriental region. Finally, when the genus gained access to Australia, it died out in most of the more northern regions except in Papua and some of the East Indian islands where it is still abundant.

The great bulk of the neotropical salientian fauna is composed of bufonids. We have shown above that there is no real distinction between those genera possessing and those lacking the maxillary teeth. I recognize thirty genera in South America and two additional genera restricted to Central America. Except for one or two stragglers in northern Mexico and Florida, none of these Salientia except *Bufo* extend their range beyond the neotropics. *Bufo* is undoubtedly a hardy migrant from some other region. It probably gained access to South America at the same time that *Rana* did. The majority of the bufonids in South America probably originated there from allied genera. Only eight of

the thirty genera in South America occur north of the Isthmus. Probably the majority of these have pushed their way northward since the Panama connection.

It is surprising that no primitive salientian except *Pipa* occurs in South America. The discoglossids and pelobatids are totally absent. The presence of *Pipa* does not prove a former land connection between South America and Africa. It cannot be too strongly emphasized that the faunæ of these two continents are very unlike. Just how a land bridge would have permitted the entrance into South America of a pipid and none of the numerous ranids (save *Rana*) which must have swarmed in Africa, one cannot explain. *Pipa*, even if greatly specialized to an aquatic existence, shows itself in its structure to be one of the most primitive Salientia. The absence of fossil record prevents us from estimating when *Pipa* may have gained access to South America, but, because of its lowly position among the Salientia, it would seem likely that this may have been in Mesozoic or early Tertiary times. There is no evidence against *Pipa* having reached South America from the north in these early days.

Australian-Papuan Fauna

Australia is very poor in Salientia, while New Guinea, although comparatively richer, possesses a fauna not unlike that of northern Queensland, except that one group, the Brevicipitidæ, has undergone a remarkable radiation. The Australian relationship of the Salientia of New Guinea has never been sufficiently emphasized. Nor has the case for a northern origin of the Australian Salientia been satisfactorily argued.

The great bulk of the salientian fauna of Australia is composed of bufonids. Fifteen genera are recognized today. Of these only three are toothless. One toothless genus, *Pseudophryne*, has been directly derived from a toothed form, *Crinia*, occurring in the same region, while the internal structure of the other two edentulous genera is not sufficiently known for us to state from what toothed bufonid they have arisen. Still, it may be safely assumed that their relations are to be sought within the region. The comparatively recent and aggressive genus *Bufo* does not occur in Australia, a condition which is to be expected if the genus, as we have assumed above, is of holarctic origin and has pushed southward only in late Tertiary or recent times.

The fact that numerous toothed bufonids occur in Australia and in South America has for many years lent some support to the Antarctic continent theory. We have already stated above that this recent dis-

covery of toothed bufonids in Africa together with a recognition of the close affinity of toothed and toothless forms removes much of the argument in favor of this view. For years the distribution of the hylids has been used as supplementary evidence in favor of a former South American-Australian land connection. But it should be emphasized that of the hylids, the genus *Hyla* alone occurs in Australia. The genus *Hylella* is untenable, for the presence or absence of vomerine teeth is a character of little significance.

The distribution of the genus *Hyla* is very difficult to explain. We have already remarked on the discovery of a *Hyla* in Abyssinia. The genus is now known from all the major zoölogical regions except for a remarkable hiatus, extending from the Philippines, Borneo, Celebes, Siam, and the Malay Archipelago through India. Several of the Asiatic Hylas encroach upon the border of this region (as in Burma), but these are readily recognizable as ectogenetic forms. Why this Indo-Oriental region should be a closed territory to *Hyla* is not known, but I do not believe there is good reason to assume that it has always been a closed territory, that the genus has never existed in any of this region.

The Hylidæ, and especially *Hyla*, are nothing but arboreal bufonids, some of which have returned again to a terrestrial existence. A close parallel occurs in the Ranidæ. A group of ranid genera are characterized by an intercalary disc between the ultimate and penultimate phalanges of the digits. Not all of these genera are arboreal. But the osteology, especially the pectoral girdle, indicates that the terrestrial have evolved from the arboreal forms. Thus it would seem that the intercalary disc once formed is never absorbed, and that the presence of this disc is indicative of an arboreal ancestry. I have had the occasion of discussing this problem in another connection (Noble, in manuscript). It is interesting to note that all hylids possess this disc, although it occurs also in other families. It is found in certain arboreal bufonids (*Centrolene*) which have retained the T-shaped terminal phalanges.

If we overlook for a moment the great gap in an almost world-wide distribution of the genus *Hyla* and recognize that the genus must have arisen from the toothed bufonids known today from the Ethiopian as well as the neotropical regions, if we admit that the toothless bufonids of this Indo-Oriental region must have arisen from toothed forms probably existing in the same or not far distant regions, then it is not difficult to understand that *Hyla*, too, may have arisen from these or related bufonids. The argument in brief is that in all probability there existed in the Indo-Oriental region toothed bufonids not found there today.

Similarly, there may have been hylids there. At least it is much simpler to account for the present distributions of the genus *Hyla* by assuming a northern origin and later migration southward by three routes, the first leading into South America, the second into Africa, and the third into the East Indies and Australia, than to assume land connections between South America and Australia when we would have still to account for the *Hylas* in Africa and northern Asia.

New Guinea and many of the East Indian islands are rich in species of *Hyla*. A second genus of hylids occurs in New Guinea. This has been considered identical with *Nyctimantis*, a South American genus, but it was recognized by Stejneger (1916) that here was a case of parallel modification and he erected for the New Guinean form a new genus, *Nyctimystes*. There can be no doubt that the single character, the vertical pupil, which distinguishes *Nyctimystes* from *Hyla* was acquired independently in the former and in the South American *Nyctimantis*.

It has been recognized for a long time that northern Queensland possessed much in common with New Guinea. For this reason, it has been called the Torresian or the Papuan district of Australia. The Salientia of this subregion are largely of those genera found in other parts of Australia but in addition there is found here a ranid and four brevicipitids. The ranid, *Rana papua*, occurs also in New Guinea, Ceram, Aru and Tenimber Islands, Batanta, Waigeu, Jobi and d'Entrecastaux Islands. It is therefore a wide-ranging species. New Guinea, according to Van Kampen (1919), possesses about nine species of *Rana*, but the status of certain of these is in doubt. The only other genus of ranids in New Guinea is *Platymantis* which has an extended distribution in the East Indies. It is apparent that the two genera of ranids in New Guinea are of recent arrival, both belonging to wide-ranging groups.

Although New Guinea has not been a center of radiation for the ranids, it has been one of the highest specialization for the brevicipitids. The four species of brevicipitids in Australia are all referable to a single genus, *Austrochaperina*, closely allied to the wide-ranging *Chaperina*. Van Kampen (1919) recognizes thirteen genera and thirty-five species of brevicipitids in New Guinea. All these lack the maxillary teeth and thus in all probability represent the extreme type of specialization. Only three of the thirteen genera of brevicipitids occur beyond New Guinea. It is therefore probable that most of the genera have probably arisen within the region. I have suggested above that the original stock from which the New Guinean brevicipitids arose was formerly widely distributed in southern Asia. This must have been a "dyscophid" stock, pos-

sessing maxillary teeth and exhibiting few losses in the pectoral girdle. Whether the southern migration through the Malayan Archipelago and the East Indies occurred before or after the loss of maxillary teeth it is impossible to say. Probably brevicipitids, both with and without the maxillary teeth, formed the original brevicipitid fauna of New Guinea.

Van Kampen (1919) records a single genus, *Lechriodus*, of pelobatids from New Guinea. I have suggested above that this genus is in all probability a bufonid. I have not had the opportunity of examining a specimen, but Fry (1915, p. 75) has figured the genus as possessing two articular condyles for the coccyx.

One other genus of bufonids, *Ranaster*, occurs in New Guinea. This is represented by only a single species. The two species of bufonids in New Guinea do not give its salientian fauna very much of an Australian facies. Nevertheless, the fauna of New Guinea is essentially like that of Queensland. There are very probably no pelobatids in New Guinea. There are no ranids except representatives of two wide-ranging genera. New Guinea shares with Queensland its brevicipitids, hylids, and bufonids. In the former region, the brevicipitids and hylids have undergone a remarkable radiation; in the latter, the bufonids have specialized along lines of their own. Although the facies of the salentian fauna of New Guinea is unlike that of Australia, nevertheless, the components of this fauna find closer affinity with the latter than with the fauna of India or the Oriental region. Still, it is highly probable that the salientian fauna of both New Guinea and Australia originated in these more northern regions.

The salientian fauna of Tasmania is merely an extension of that of Australia. According to English (1910), only seven species occur on the island and these are referable to the four genera *Limnodynastes, Crinia, Pseudophryne,* and *Hyla.*

Only two indigenous species of Saientia occur in New Zealand[1] but these are of great interest. They are both referable to the genus *Liopelma.* This genus has long been known as a discoglossid but recently Boulenger (1910) without giving any reason has referred it to the "leptodactylids" or toothed bufonids. It is apparent that some skeletal material was available to Boulenger, but of this I have no information. It came as a distinct surprise to me to find McCulloch (1919) describing a second species of *Liopelma* and referring the genus without comment to the Discoglossidæ. There is no doubt in my mind that the genus is a dis-

[1]There are also two introduced species.

coglossid. The pectoral girdle figured by McCulloch (1919, figs. 1 and 2) is unlike that of any bufonid but agrees very well with that of *Ascaphus*. It is unfortunate that McCulloch did not make a complete dissection of *Liopelma hamiltoni* and settle the exact relations of the genus.

Stejneger (1905) would make the "country south-east of the Himalayas as the original center of radiation of the discoglossoid toads." There is much evidence to believe that this is the correct interpretation. It is to be noted that wide areas formerly occupied according to this view by discoglossids are now totally devoid of them. The Discoglossidæ, being the oldest family of Salientia, would be the most apt to show a discontinuous distribution. Following this same reasoning, the pipids would exhibit the next most discontinuous range, while the bufonids and hylids would have a more scattered distribution than the ranids, brevicipitids, or brachycephalids. It will be noted that the facts of distribution given above agree very well with this hypothesis, although some exceptions may be made, as in the case of the Pelobatidæ which, although primitive, exhibit a fairly continuous range. *Hyla* is not a recent genus, even if not a very archaic one. Its distribution would be expected to be more discontinuous than that of *Rana*, *Bufo*, etc. In fact, it is probable that in former times its distribution was more discontinuous than it is today, for the Asiatic *Hylas* seem to be recent arrivals from the west. In passing, a comparison may be made between the distribution of *Hyla* and that of the marsupials. The present ranges do not agree exactly, but in both they are discontinuous. Yet, in the case of the marsupials, the fossil evidence seems to demand a former wide distribution in the holarctic region and a later migration southward into Australia on one hand and South America on the other.

Indo-Oriental Fauna

Little need be said about the origin of this fauna for it has never been the subject of very much dispute. It is primarily a recent fauna showing closest affinities with that of Africa and Madagascar. It is rich in ranids, brevicipitids, and toothless bufonids, all more or less allied to African genera. The unique feature of this fauna is the abundance of pelobatids. The center of dispersal of the Pelobatidæ cannot be determined until the structure of more genera has been investigated. Still, it is safe to assume that this center was in the Palæarctic region. In fact, there is good reason to believe that the entire salientian fauna of India and southeastern Asia has migrated into the region from more northern realms.

Holarctic Fauna

Nor is it necessary for us to consider in detail the Salientia of the Palæarctic and Nearctic regions. As is well known, these regions are poor in Salientia. Some of the forms at present found there may have come in from more southern climates. There has been much easterly and westerly migration in the Palæarctic realm. In the Nearctic, the migrations seem to have been chiefly from the north to the south.

SUMMARY

Taxonomy and Phylogeny

(1). The classification of the Salientia in general use is largely artificial. Although this has been recognized, no better classification has been proposed but certain welcome changes in the system have been made.

(2). A review of the osteology of the Salientia with a view to determining characters of phylogenetic significance has shown that the maxillary teeth are lost at the end stages of many different lines of specialization and that their absence has no taxonomic significance. Further, the development of pseudo-teeth (in one case true teeth) on the lower jaw must also be considered an extreme case of specialization and without phylogenetic importance. In former classifications, considerable value was placed on the form of the sacral diapophyses in determining relations, also on the structure of the pectoral girdle and on certain features in the skull. A critical examination of the evidence makes it necessary to reject any of these characters as of primary importance.

(3). The modifications of the vertebral column offer a basis of dividing the Salientia into four primary groups, or suborders. Other features, such as the presence or absence of ribs, support this arrangement. The four suborders may again be divided into families on the basis of the most stable osteological characters at present known.

(4). In eliminating the variable characters, it becomes necessary to delete from the system the families based upon them. The following families have been rejected: Dendrobatidæ, Ceratobatrachidæ, Genyophrynidæ, Hemiphractidæ, Amphignathodontidæ, Dendrophryniscidæ, Leptodactylidæ and Dyscophidæ.

(5). A combination of characters in the vertebral column and thigh musculature distinguishes a group of neotropical genera from the ranids and brevicipitids which they parallel while the structure of their pectoral girdle distinguishes them from their bufonid progenitors. For this group I have erected the name Brachycephalidæ.

(6). The modifications of the thigh musculature exhibited by the families of Salientia, especially the arrangements of the distal tendons of the sartorius, semitendinosus, and gracilis major and minor, agree entirely with the classification proposed and not completely with any other scheme.

(7). This agreement of myological and osteological data makes it appear that the classification proposed is a natural one, while all other schemes are artificial to a greater or less extent.

(8). The phylogeny of the Salientia exhibits a series of orthogenetic and often parallel modifications. Adaptation seems to have been only slightly correlated with the major changes in the evolution of the group. As shown in the chart certain modifications, such as the loss of teeth or the fusion of the pectoral girdle in the midline, have taken place at the end stages of specialization in several different lines. It is not apparent that these and many other modifications of the Salientia are adaptive. This unadaptive phylogeny of the Salientia stands in striking contrast to that of the Caudata, which seems to have been closely correlated with the habits and habitats of the respective families.

(9). The classification proposed removes many difficult problems of distribution which existed under the former schemes. It becomes quite unnecessary to assume hypothetical land bridges to account for the present distribution of the Salientia. All the families of frogs and toads except the Brachycephalidæ seem to have originated in the Holarctic regions, or at least in the northern hemisphere and to have pushed southward into southern regions. Migrations in other directions also occurred, but no family of Salientia except the recently derived Brachycephalidæ had their center of dispersal on a southern continent.

Myology

(1). A comparison of the thigh musculature and its innervation throughout a large series of genera has shown many modifications even within a family. The adductor longus must be regarded as a mere slip of the pectineus, not differentiated in the more generalized forms. Similarly, the sartorius is only the anterior portion of a primitively broad and superficial muscle, the sartorio-semitendinosus. The gracilis minor may be regarded as a specialized slip of the gracilis major and primitively attaching to the skin.

(2). The most primitive type of thigh musculature is found in the more generalized discoglossids. In addition to the absence of an adductor longus and a sartorius, there is no accessory head to the adductor magnus. The latter muscle consists primitively of two very distinct muscles, which partly fuse in the advanced types. The semitendinosus is represented in the posterior part of a broad muscle which lies superficial on the ventral surface of the thigh. The obturator externus and the tensor fasciæ latæ are well-developed muscles (in general) showing that

their condition in higher types is due to a reduction in size. Other muscles, such as the iliacus externus, have a more generalized form than in higher forms.

(3). *Ascaphus* is remarkable in possessing two pairs of coccygeal muscles attaching to the thigh. The posterior pair is doubtlessly homologous to the caudalipuboischiotibialis of the urodeles. These two pairs of muscles are in no way associated with the "tail" of the male *Ascaphus*, which is purely a copulatory organ formed chiefly by an extension of the cloaca.

(4). In homologizing the thigh musculature of the Salientia with that of the Caudata, little difficulty is experienced when comparing primitive forms. The homologies suggested by the relative position, origin, and insertions of the muscles are fully supported by the innervations. These homologies have been tabulated above.

(5). Few modifications occur in the thigh musculature of the Caudata. These modifications have not been understood by earlier investigators. Two muscles, the adductor femoris and the iliotibialis, have been confused in most accounts with other muscles. The innervation, as well as the relative arrangement, indicates the distinctness of these muscles.

(6). It is inferred that the Pro-Salientia retained a pelvic musculature similar to the Caudata. The muscle areas on the pelvis of *Eryops* suggest this, while the presence of two pairs of coccygeo-femoral muscles in *Ascaphus* and the urodele appearance of the thigh musculature in all primitive Salientia seem to confirm this inference. This may not indicate a closer affinity of Salientia and Caudata than hitherto believed, but it may permit us to assume that the ancestral Caudata, Salientia, and possibly Reptilia possessed a type of pelvic musculature that was essentially alike.

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Explanations of Abbreviations in Plates I–XXIII

Add. fem. = Adductor femoris
Add. long. = Adductor longus
Add. mag. = Adductor magnus
(cap. ventr.) = ventral head
(cap. dors.) = dorsal head
(cap. acc.) = accessory head
Ang. = Angular
Art. = Articular
Bind. lig. = Binding ligament
Cart. Meck. = Meckel's cartilage
Caud. fem. = Caudalifemoralis
C.p.i.t. = Caudalipuboischiotibialis
Caud. pubo. isch. tib. = Caudalipuboischiotibialis
Cocc. = Coccyx
Cocc. il. = Coccygeo-iliacus
Compr. cloac. = Compressor cloacæ
Crur. = Cruralis
Dent. = Dentary
Fem. fib. = Femorofibularis
Gem. = Gemellus
Glut. = Glutæus
Grac. maj. = Gracilis major
Grac. min. = Gracilis minor
Il. ex. = Iliacus externus
Il. ext. = Ilio-externsorius
Il. fem. = Iliofemoralis
Il. fib. = Iliofibularis
Il. tib. = Iliotibialis
Il. int. = Iliacus internus
Isch. cut. = Ischiocutaneus
Isch. fem. = Ischiofemoralis
Isch. flex. = Ischioflexorius
Lat. dors. = Latissimus dorsi
N. fem. = Femoralis nerve
N. iliohyp. = Iliohypogastric nerve
N. isch. = Ischiadic nerve
N. obt. = Obturator nerve
N. peron. = Peroneus nerve
Obl. ext. = Obliquus externus
Obl. int. = Obliquus internus
Obt. ext. = Obturator externus
Obt. int. = Obturator internus
Os il. = Ilium
Pect. = Pectineus
Peron. = Peroneus
P.i.f.e. = Puboischiofemoralis externus
P.i.f.i. = Puboischiofemoralis internus
P.i.t. = Puboischiotibialis
Plant. long. = Plantaris longus
P. mentalis. = Pars mentalis
post-pub. = Postpubis
pre-pub. = Prepubis
pubo. isch. = Puboischium
P.t. = Pubotibialis
Pub. isch. fem. ext. = Puboischiofemoralis externus
Pub. isch. fem. int. = Puboischiofemoralis internus.
Pub. isch. tib. = Puboischiotibialis
Pub. tib. = Pubotibialis
Pul. = Pulmonary muscle
Pyrif. = Pyriformis
Quad. fem. = Quadratus femoris
R. cut. fem. lat. = Ramus cutaneus femoris lateralis
Rect. abd. = Rectus abdominis
Sac. = Sacrum
Sart. = Sartorius
Sart.-semitend. = Sartorio-semitendinosus
(cap. semitend.) = Semitendinosus head of sartorio-semitendinosus
Sec. lig. = Secondary ligament
Semimbr. = Semimembranosus
Semitend. = Semitendinosus
Sph. an. cl. = Sphincter ani cloacalis
Tend. grac. = Tendon of the gracilis major and minor
Tend. sart. = Tendon of the sartorius
Tend. semitend. = Tendon of the semitendinosus
Tens. fasc. lat. = Tensor fasciæ latæ
Tib. ant. long. = Tibialis anticus longus

Plate I

Mandibular "teeth" of various Salientia. Tooth-like protuberances are found on the lower jaw of various specialized genera. Only in *Amphignathodon* (Figs. 5 and 6) are these true teeth, in all other genera they are mere processes of the bony elements composing the lower jaw and to be compared with excess bony growths on other parts of the skull.

Fig. 1. *Cerathyla johnsoni* Noble, medial aspect of mandible, A. M. N. H. No. 1343.

Fig. 2. Same, outer aspect.

Fig. 3. *Dimorphognathus africanus* (Hallowell), medial aspect of mandible, A. M. N. H. No. 11294.

Fig. 4. Same, outer aspect.

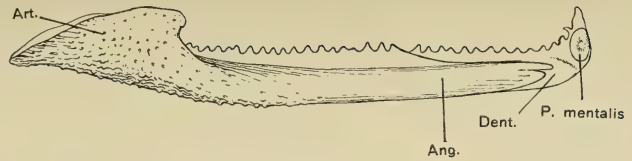
Fig. 5. *Amphignathodon güntheri* Boulenger, medial aspect of mandible, collection of University of Michigan.

Fig. 6. Same, outer aspect.

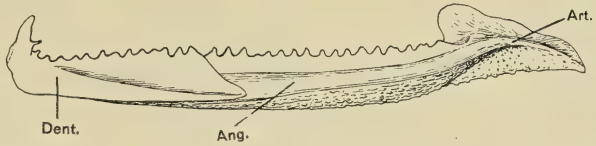
Fig. 7. *Ceratobatrachus guentheri* Boulenger, medial aspect of mandible, A. M. N. H. No. 5335.

Fig. 8. Same, outer aspect.

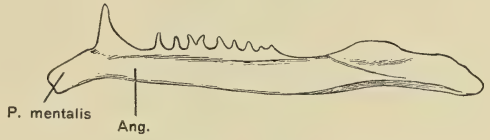
1


Art.
Dent.
P. mentalis
Ang.

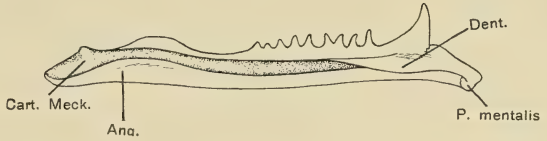
2


Art.
Dent.
Ang.

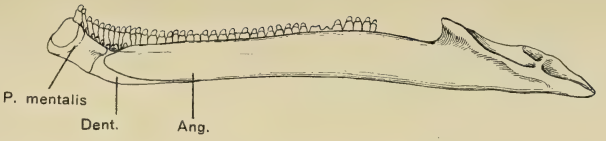
3


P. mentalis
Ang.

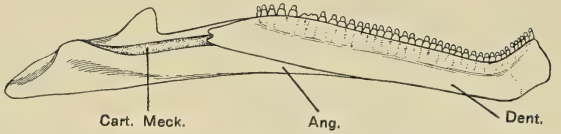
4


Dent.
Cart. Meck.
Ang.
P. mentalis

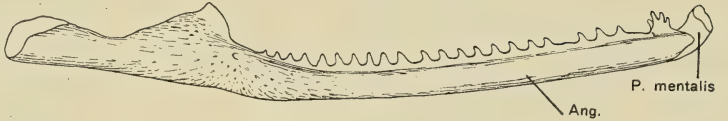
5


P. mentalis
Dent.
Ang.

6


Cart. Meck.
Ang.
Dent.

7


P. mentalis
Ang.

8

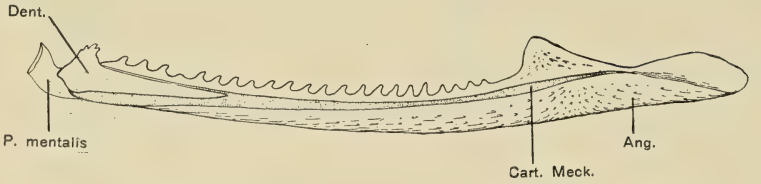
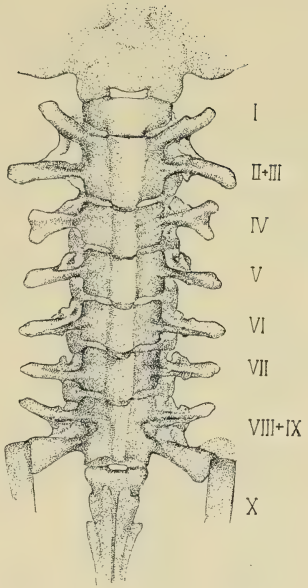
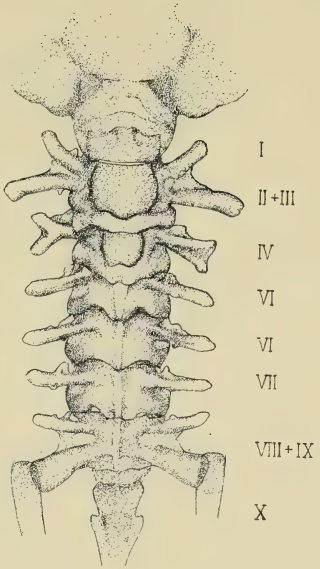

Dent.
P. mentalis
Ang.
Cart. Meck.

Plate II

Dendrobates typographus Keferstein. Vertebral column as seen from lower (Fig. 1) and upper (Fig. 2) surfaces. Vertebral column of an immature specimen (Fig. 3) showing early fusion of vertebræ.


I
II+III
IV
V
VI
VII
VIII+IX
X

1


I
II+III
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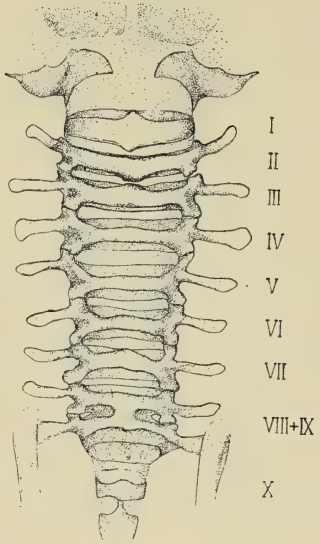
VII
VIII+IX
X

2


I
II
III
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VI
VII
VIII+IX
X

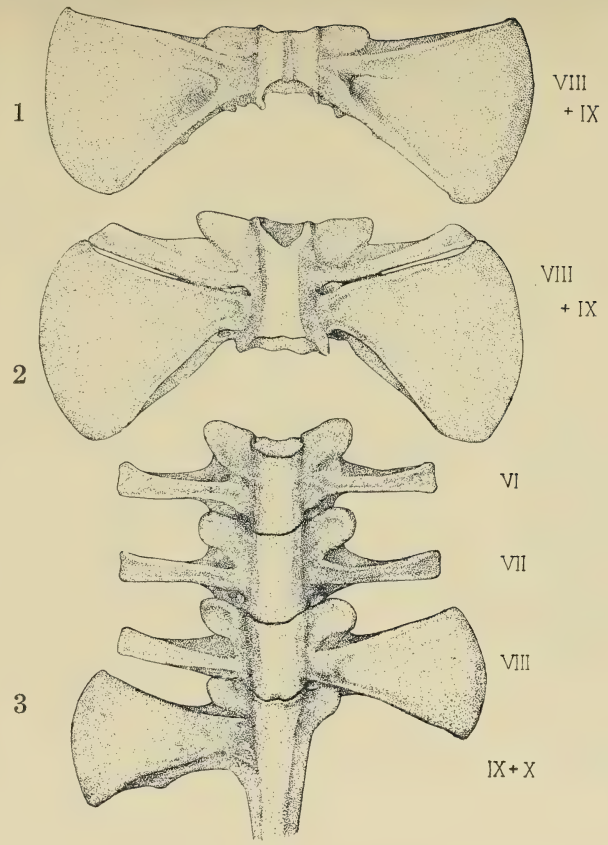
3

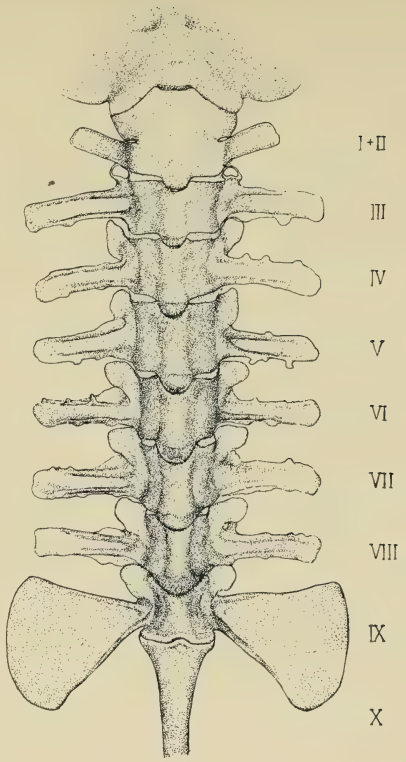
Plate III

Atelopus varius Stannius.

Figs. 1 to 3. Abnormal sacra, ventral aspect.

Fig. 4. Normal vertebral column, ventral aspect.





4

Plate IV

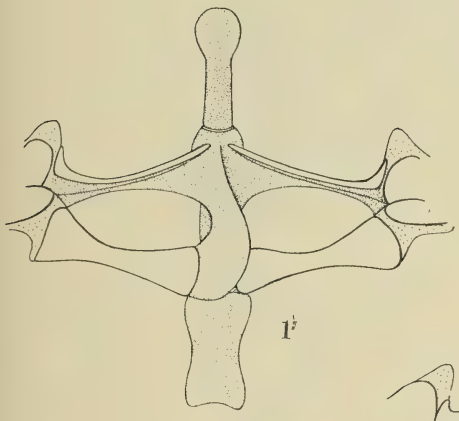
Pectoral girdles as seen from dorsal (medial) side. The series illustrates the change from the arciferal to the firmisternal type.

Fig. 1. *Eleutherodactylus bransfordii* (Cope).

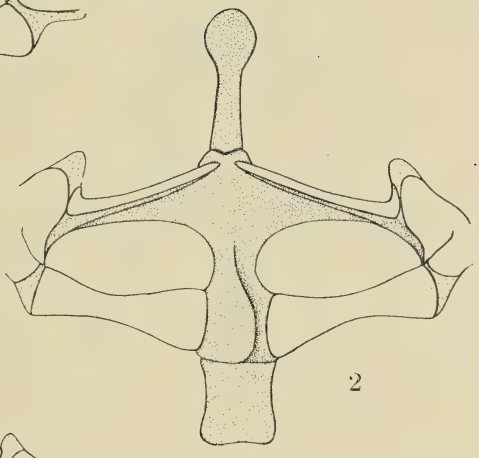
Fig. 2. *Sminthillus peruvianus* Noble.

Fig. 3. *Sminthillus limbatus* (Cope).

Fig. 4. *Rhinoderma darwinii* Duméril and Bibron.



1½



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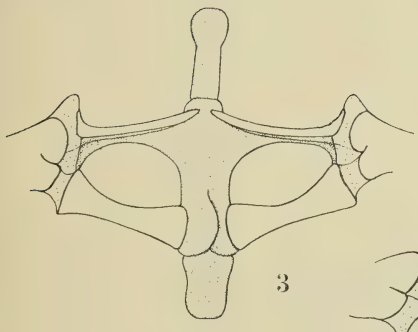

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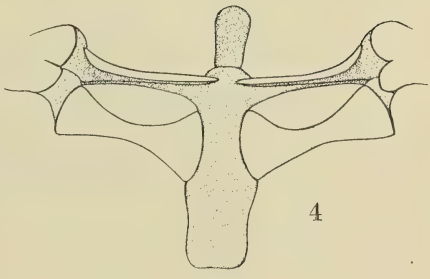


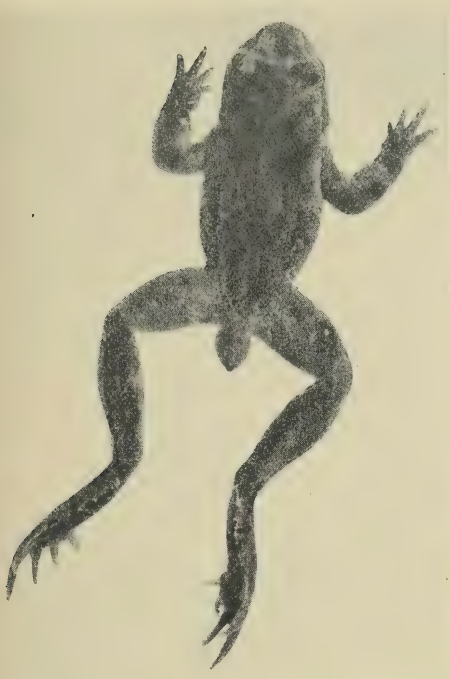
4

Plate V

Ascaphus truei Stejneger. Photographs to show variation in shape of the "tail."

Figs. 1 and 2. Freshly killed specimen floating in water, the "tail" somewhat dilated.

Fig. 3. Living specimen playing dead, the "tail" reduced in width.



1

2

3

Plate VI

Thigh Muscles of *Ascaphus truei* Stejneger (male).

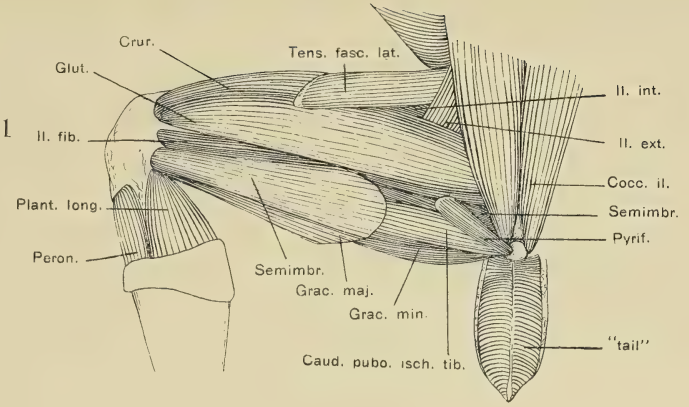
Fig. 1. Dorsal aspect, superficial muscles.

Fig. 2. Ventral view, superficial muscles.

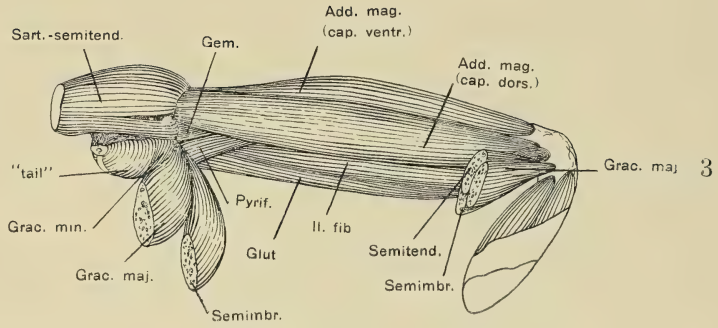
Fig. 3. Posterior aspect of thigh, the superficial muscles cut and turned aside.

Fig. 4. Same aspect, showing the deep muscles of the thigh.

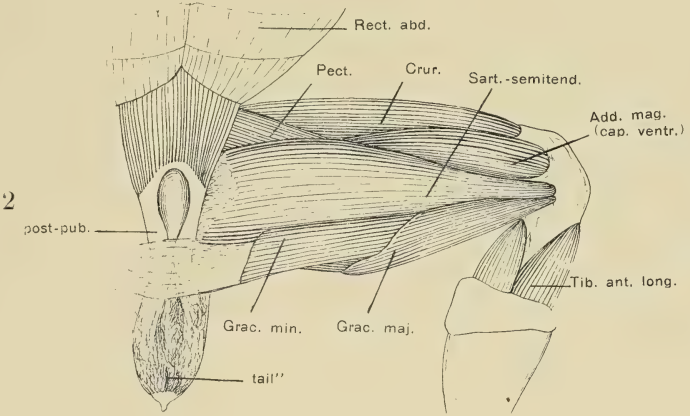
For explanation of abbreviations see page 87.


Crur.
Glut.
Tens. fasc. lat.
Il. int.
Il. ext.
Il. fib.
Cocc. il.
Plant. long.
Semimbr.
Pyrif.
Peron.
Semimbr.
Grac. maj.
Grac. min.
Caud. pubo. isch. tib.
"tail"

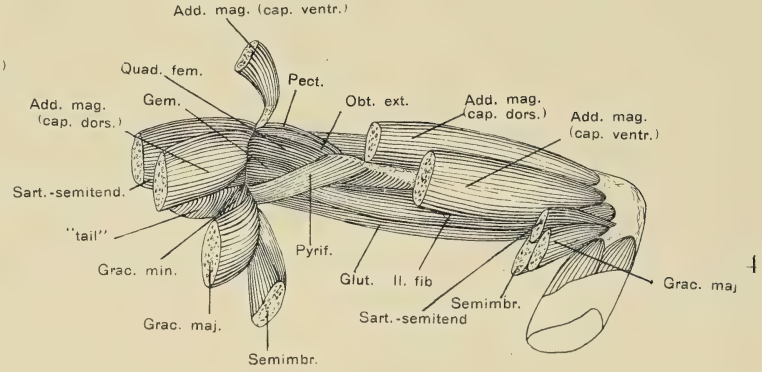
1


Sart.-semitend.
Gem.
Add. mag. (cap. ventr.)
Add. mag. (cap. dors.)
"tail"
Grac. maj
Pyrif.
Grac. min.
Il. fib
Glut
Semitend.
Grac. maj.
Semimbr.
Semimbr.

3


Rect. abd.
Pect.
Crur.
Sart.-semitend.
Add. mag. (cap. ventr.)
post-pub.
Tib. ant. long.
Grac. min.
Grac. maj.
tail"

2


Add. mag. (cap. ventr.)
Quad. fem.
Pect.
Add. mag. (cap. dors.)
Gem.
Obt. ext.
Add. mag. (cap. dors.)
Add. mag. (cap. ventr.)
Sart.-semitend.
"tail"
Pyrif.
Grac. min.
Glut.
Il. fib
Grac. maj
Semimbr.
Grac. maj.
Sart.-semitend
Semimbr.

4

Plate VII

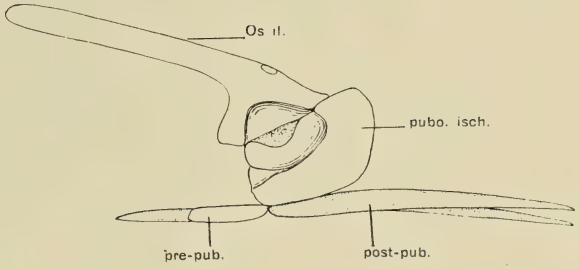
Pelvis of *Ascaphus truei* Stejneger (male).

Fig. 1. Lateral aspect.

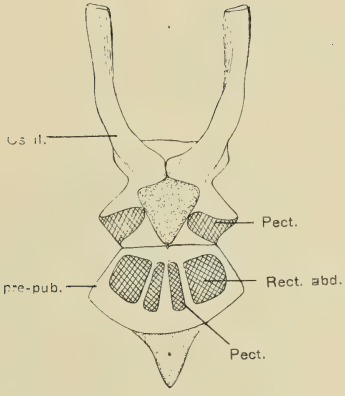
Fig. 2. Anterior aspect, showing muscle areas.

Fig. 3. Ventral aspect.

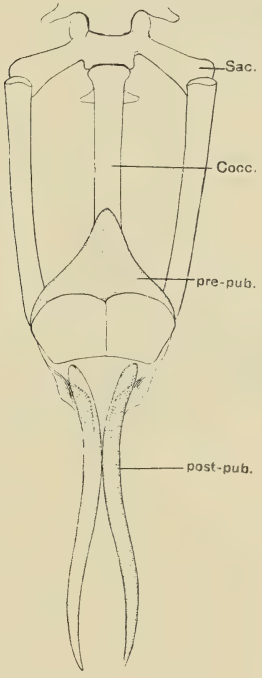
Cartilage even stipple, semi-calcified irregular stipple, calcified or bony structures in outline.


Os il.
pubo. isch.
pre-pub.
post-pub.

1


Os il.
Pect.
pre-pub.
Rect. abd.
Pect.

2


Sac.
Cocc.
pre-pub.
post-pub.

3

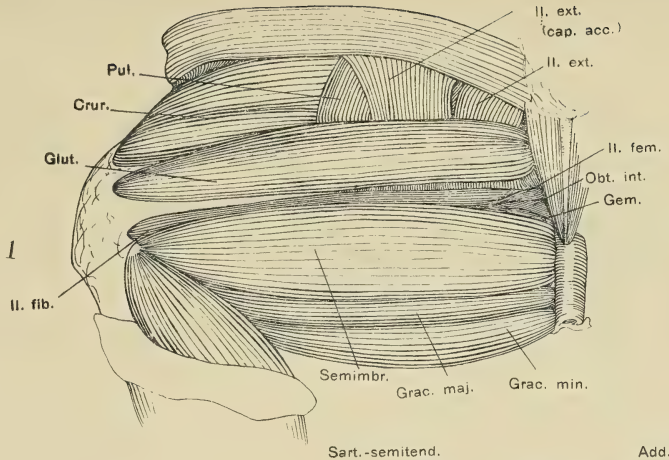
Plate VIII

Thigh Muscles of *Pipa pipa* (Linné).

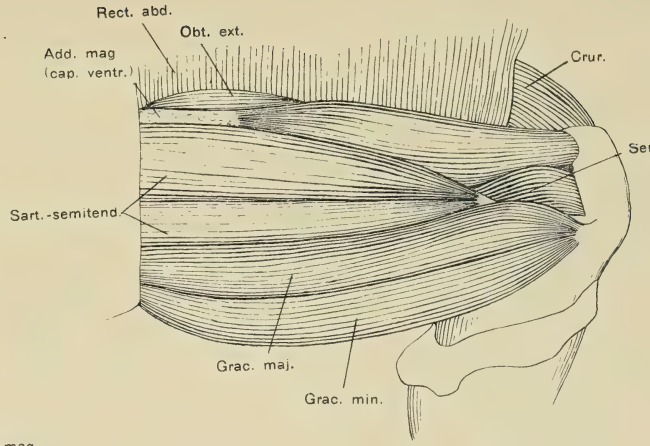
Fig. 1. Dorsal aspect, superficial muscles.

Fig. 2. Ventral aspect, superficial muscles.

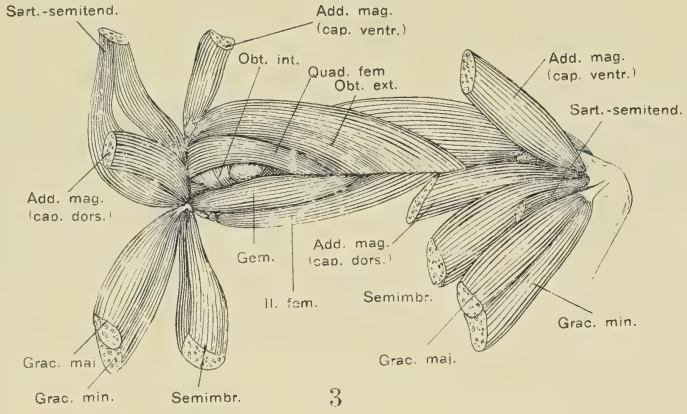
Fig. 3. Deep muscles of the thigh as viewed posteriorly.


Il. ext.
(cap. acc.)
Il. ext.
Put.
Crur.
Glut.
Il. fem.
Obt. int.
Gem.
Il. fib.
Semimbr.
Grac. maj.
Grac. min.

1


Rect. abd.
Obt. ext.
Add. mag
(cap. ventr.)
Crur.
Semimbr.
Sart.-semitend
Grac. maj.
Grac. min.

2


Sart.-semitend.
Add. mag.
(cap. ventr.)
Obt. int.
Quad. fem
Obt. ext.
Add. mag.
(cap. ventr.)
Sart.-semitend.
Add. mag.
(cap. dors.)
Gem.
Add. mag.
(cap. dors.)
Il. fem.
Semimbr.
Grac. min.
Grac. mai
Grac. mai.
Grac. min.
Semimbr.

3

Plate IX

Thigh Muscles of *Hymenochirus boettgeri* (Tornier).

Fig. 1. Dorsal aspect, superficial muscles.

Fig. 2. Ventral aspect, superficial muscles.

Fig. 3. Ventral view of the thigh, the more superficial muscles cut and turned aside

Fig. 4. Posterior aspect of the thigh, showing the deep muscles.

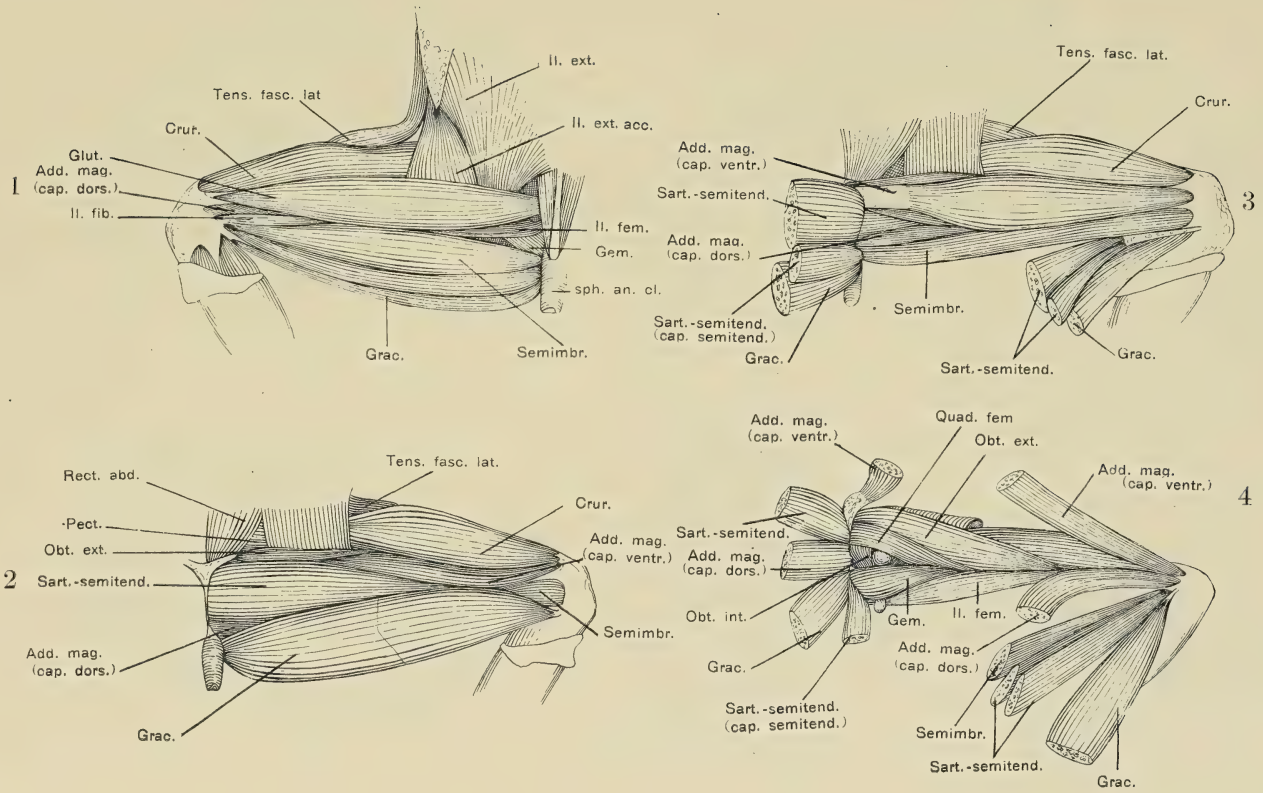

1
Il. ext.
Tens. fasc. lat
Il. ext. acc.
Crur.
Glut.
Add. mag. (cap. dors.)
Il. fib.
Il. fem.
Gem.
sph. an. cl.
Grac.
Semimbr.
3
Tens. fasc. lat.
Crur.
Add. mag. (cap. ventr.)
Sart.-semitend.
Add. mag. (cap. dors.)
Semimbr.
Sart.-semitend. (cap. semitend.)
Grac.
Sart.-semitend.
Grac.
2
Tens. fasc. lat.
Rect. abd.
Crur.
Pect.
Add. mag. (cap. ventr.)
Obt. ext.
Sart.-semitend.
Semimbr.
Add. mag. (cap. dors.)
Grac.
4
Add. mag. (cap. ventr.)
Quad. fem
Obt. ext.
Add. mag. (cap. ventr.)
Sart.-semitend.
Add. mag. (cap. dors.)
Obt. int.
Gem.
Il. fem.
Add. mag. (cap. dors.)
Grac.
Sart.-semitend. (cap. semitend.)
Semimbr.
Sart.-semitend.
Grac.

Plate X

Thigh muscles of *Xenopus mülleri* (Peters).

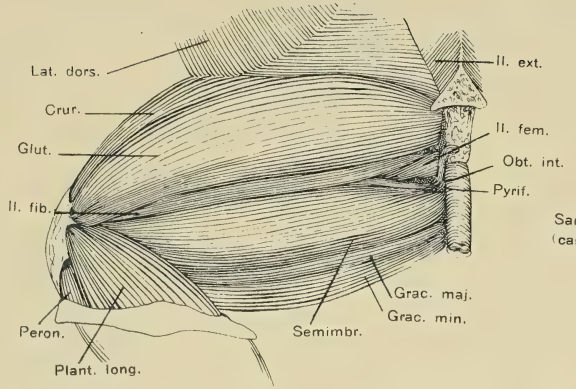
Fig. 1. Dorsal aspect of thigh, showing superficial muscles.

Fig. 2. Ventral view of thigh, superficial musculature in place.

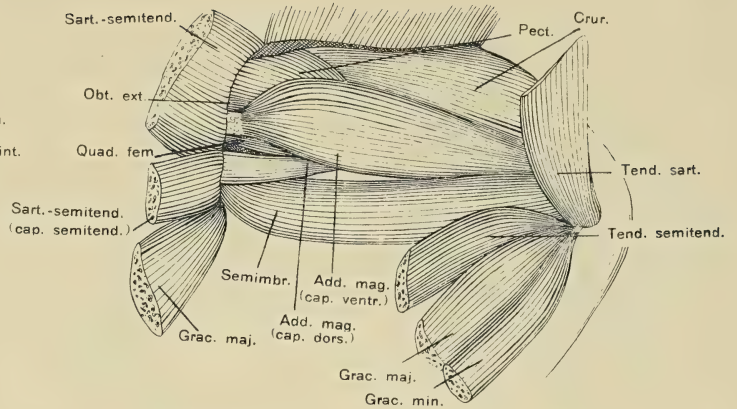
Fig. 3. Ventral view, superficial muscles cut and laid back.

Fig. 4. Posterior aspect, showing the deep muscles of the thigh.

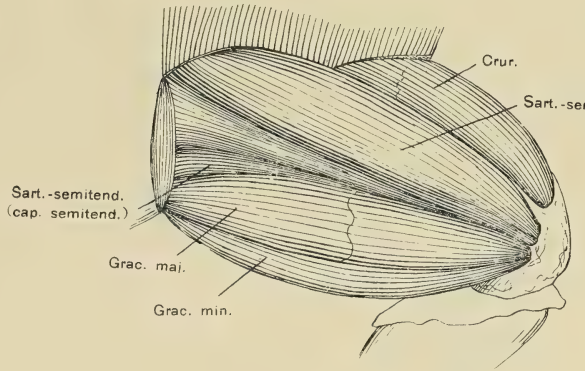
1


Lat. dors.
Crur.
Glut.
Il. fib.
Peron.
Plant. long.
Il. ext.
Il. fem.
Obt. int.
Pyrif.
Grac. maj.
Grac. min.
Semimbr.

3


Sart.-semitend.
Pect.
Crur.
Obt. ext
Quad. fem.
Tend. sart.
Sart.-semitend. (cap. semitend.)
Tend. semitend.
Semimbr.
Add. mag. (cap. ventr.)
Add. mag. (cap. dors.)
Grac. maj.
Grac. maj.
Grac. min.

2


Crur.
Sart.-semitend.
Sart.-semitend. (cap. semitend.)
Grac. maj.
Grac. min.

4

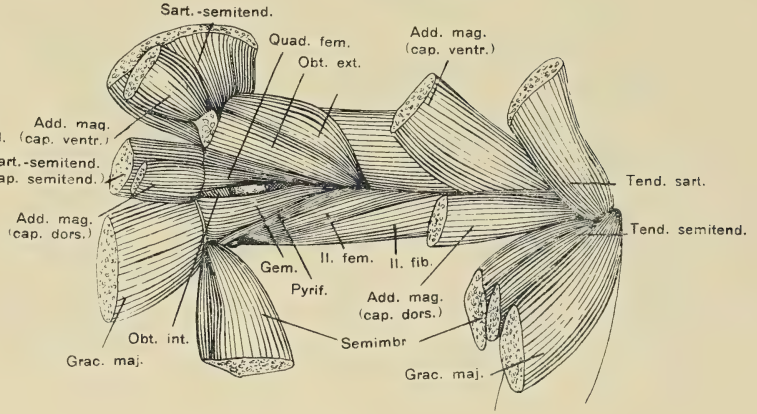

Sart.-semitend.
Quad. fem.
Obt. ext.
Add. mag. (cap. ventr.)
Add. mag. (cap. ventr.)
Sart.-semitend. (cap. semitend.)
Tend. sart.
Add. mag. (cap. dors.)
Tend. semitend.
Gem.
Il. fem.
Il. fib.
Pyrif.
Add. mag. (cap. dors.)
Obt. int.
Semimbr
Grac. maj.
Grac. maj.

Plate XI

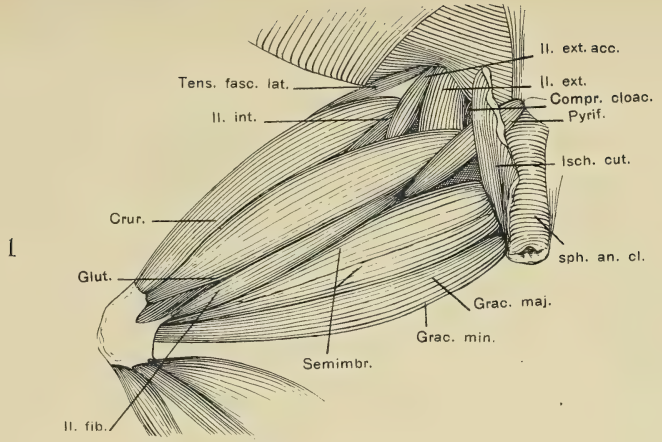
Thigh muscles of *Scaphiopus holbrookii* (Harlan).

Fig. 1. Dorsal view of superficial musculature.

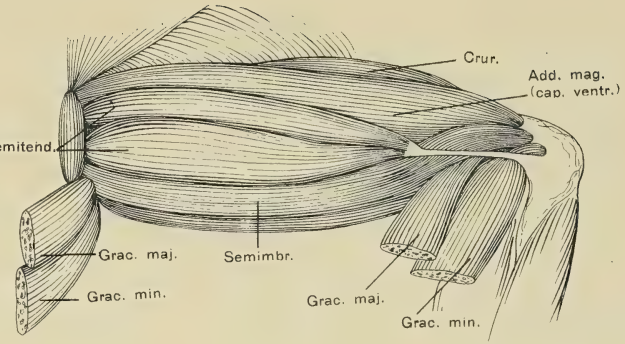
Fig. 2. Ventral of view of same.

Fig. 3. Posterior aspect of thigh, the gracilis major and minor cut, exposing the deeper muscles.

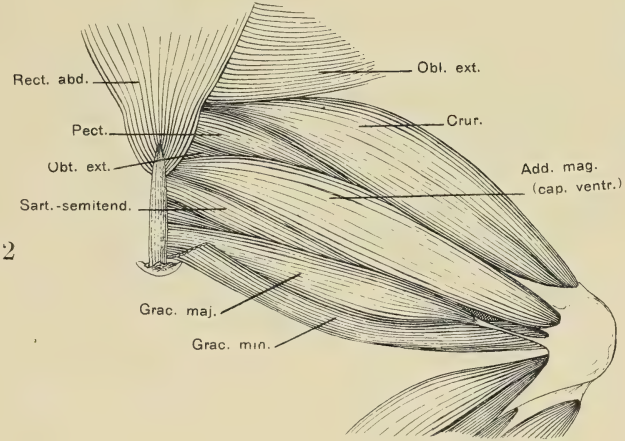
Fig. 4. Posterior view of thigh, the deep muscles exposed.


Il. ext. acc.
Tens. fasc. lat.
Il. ext.
Compr. cloac.
Il. int.
Pyrif.
Isch. cut.
Crur.
sph. an. cl.
Glut.
Grac. maj.
Grac. min.
Semimbr.
Il. fib.

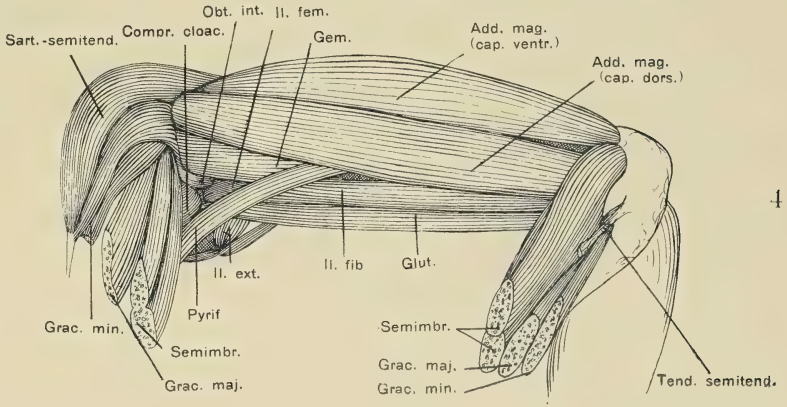
1


Crur.
Add. mag.
(cap. ventr.)
Sart.-semitend.
Grac. maj.
Semimbr.
Grac. min.
Grac. maj.
Grac. min.

3


Rect. abd.
Obl. ext.
Crur.
Pect.
Obt. ext.
Add. mag.
(cap. ventr.)
Sart.-semitend.
Grac. maj.
Grac. min.

2


Obt. int.
Il. fem.
Sart.-semitend.
Compr. cloac.
Gem.
Add. mag.
(cap. ventr.)
Add. mag.
(cap. dors.)
Il. ext.
Il. fib
Glut.
Pyrif
Grac. min.
Semimbr.
Grac. maj.
Semimbr.
Grac. maj.
Grac. min.
Tend. semitend.

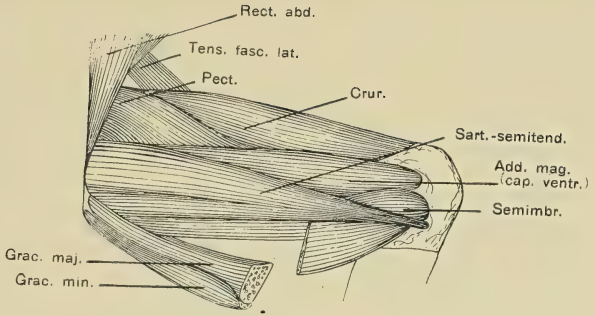
4

Plate XII

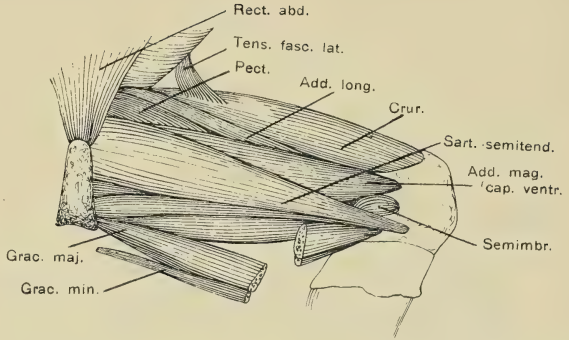
Ventral thigh musculature of the pelobatids. Series illustrating the differentiation of the adductor longus as a slip of the pectineus; also, showing the specialization of the sartorio-semitendinosus.

Fig. 1. *Megalophrys hasseltii* (Tschudi).
Fig. 2. *Megalophrys montana* Kuhl.
Fig. 3. *Pelobates fuscus* (Laurenti).
Fig. 4. *Pelodytes punctatus* (Daudin).

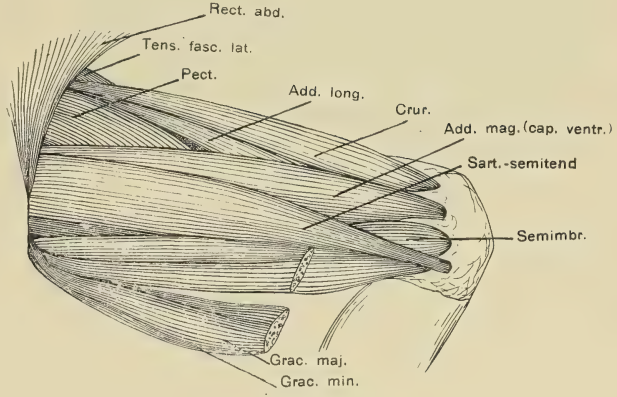
1


Rect. abd.
Tens. fasc. lat.
Pect.
Crur.
Sart.-semitend.
Add. mag.
(cap. ventr.)
Semimbr.
Grac. maj.
Grac. min.

3


Rect. abd.
Tens. fasc. lat.
Pect.
Add. long.
Crur.
Sart.-semitend.
Add. mag.
(cap. ventr.
Semimbr.
Grac. maj.
Grac. min.

2


Rect. abd.
Tens. fasc. lat.
Pect.
Add. long.
Crur.
Add. mag.(cap. ventr.)
Sart.-semitend
Semimbr.
Grac. maj.
Grac. min.

4

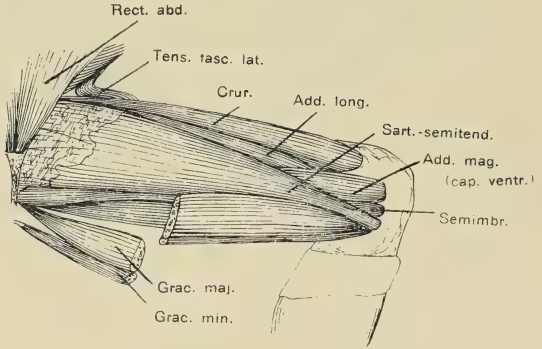
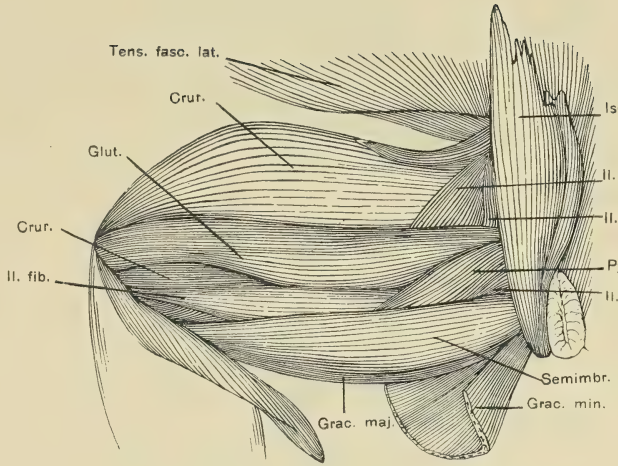

Rect. abd.
Tens. fasc. lat.
Crur.
Add. long.
Sart.-semitend.
Add. mag.
(cap. ventr.)
Semimbr.
Grac. maj.
Grac. min.

PLATE XIII

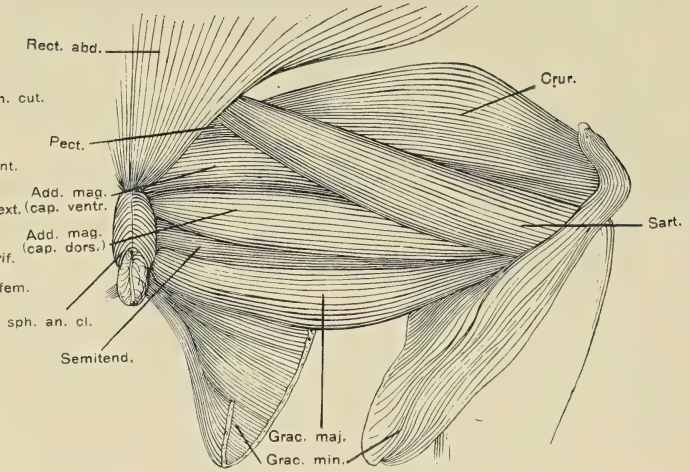
Superficial musculature of *Rhinophrynus dorsalis* Duméril and Bibron.

Fig. 1. Dorsal aspect.

Fig. 2. Ventral aspect.


Tens. fasc. lat.
Crur.
Glut.
Crur.
Il. fib.
Isch. cut.
Il. int.
Il. ext.
Pyrif.
Il. fem.
Semimbr.
Grac. min.
Grac. maj.

1


Rect. abd.
Pect.
Add. mag. (cap. ventr.
Add. mag. (cap. dors.)
sph. an. cl.
Semitend.
Crur.
Sart.
Grac. maj.
Grac. min.

2

Plate XIV

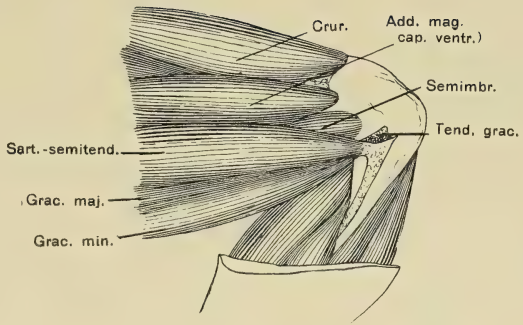
Distal tendons of the thigh.

Fig. 1. *Bombina maxima* (Boulenger), exhibiting the primitive type of complex, from which the more advanced types have evolved.

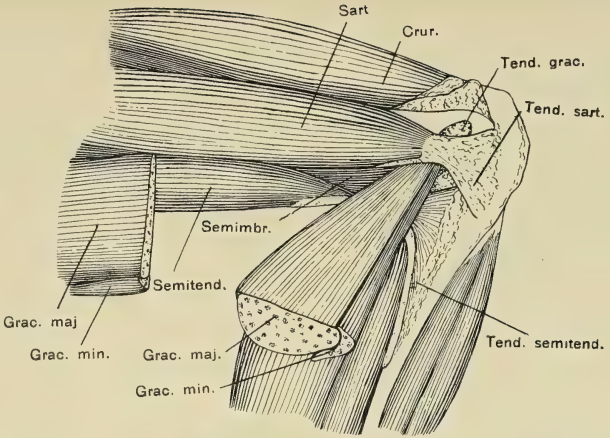
Fig. 2. *Leptodactylus pentadactylus* (Laurenti), illustrating the typical bufonid type.

Fig. 3. *Rana clamitans* Latreille, an example of the ranid type of complex.

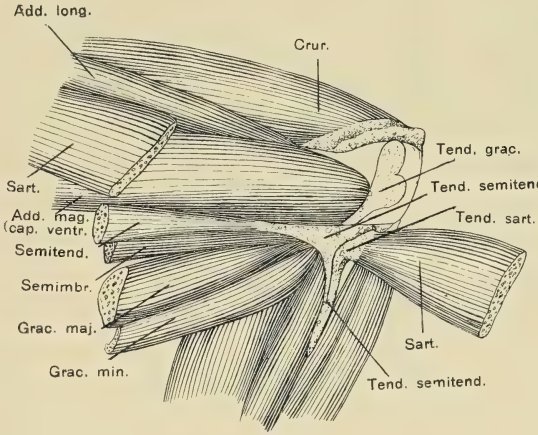
Fig. 4. *Atelopus ignescens* (Cornalia), although firmisternal, exhibiting the bufonid plan of complex. Compare with Fig. 2.


Crur.
Add. mag.
cap. ventr.)
Semimbr.
Tend. grac.
Sart.-semitend.
Grac. maj.
Grac. min.

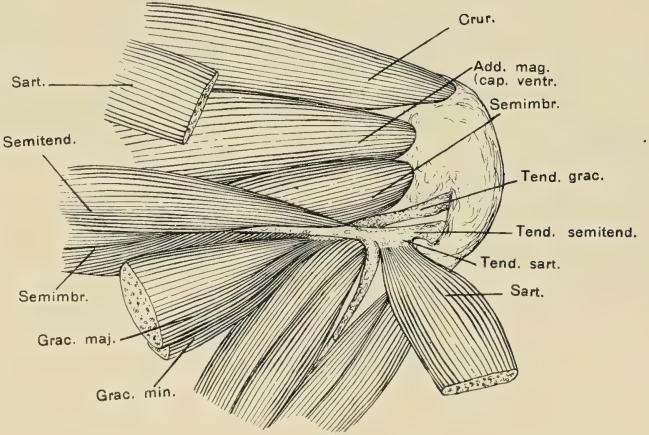
1


Sart
Crur.
Tend. grac.
Tend. sart.
Semimbr.
Semitend.
Grac. maj
Grac. min.
Grac. maj.
Grac. min.
Tend. semitend.

3


Add. long.
Crur.
Tend. grac.
Sart.
Tend. semitend.
Add. mag.
(cap. ventr.
Tend. sart.
Semitend.
Semimbr.
Grac. maj.
Sart.
Grac. min.
Tend. semitend.

2


Crur.
Sart.
Add. mag.
(cap. ventr.
Semimbr.
Semitend.
Tend. grac.
Tend. semitend.
Tend. sart.
Semimbr.
Sart.
Grac. maj.
Grac. min.

4

Plate XV

Specialization of the distal tendons of the thigh as exhibited by the Procœla.

Fig. 1. *Pleurodema bibronii* Tschudi, retaining the typical bufonid plan of complex.

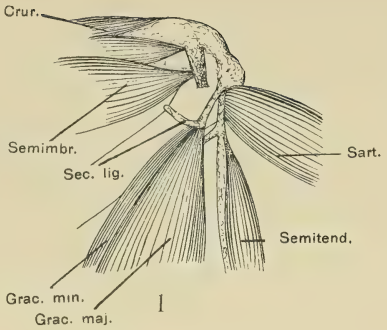
Fig. 2. *Pleurodema cinerea* Cope, intermediate stage in the sinking of the distal tendon of semitendinosus through the gracilis major.

Fig. 3. *Pleurodema brachyops* (Cope), final stage of specialization exhibited by the genus.

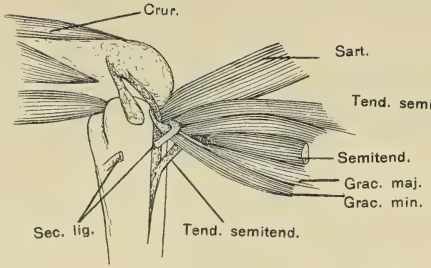
Fig. 4. *Limnodynastes ornatus* (Gray), intermediate stage in the sinking of the tendon of the semitendinosus through the gracilis mass.

Fig. 5. *Pseudophryne australis* (Gray), extreme stage of specialization found in the Procœla. Compare with Fig. 6 and with tendon complex in *Rana* (Pl. XIV, fig. 3).

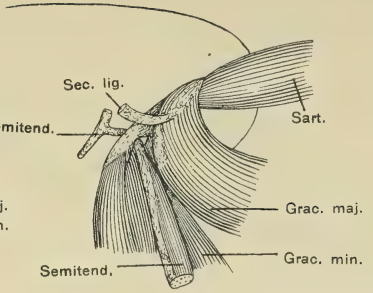
Fig. 6. *Hyloxalus granuliventris* (Boulenger), extreme stage of specialization; the brachycephalids and bufonids have independently evolved this modification of the bufonid plan of complex.


Crur.
Semimbr.
Sec. lig.
Sart.
Semitend.
Grac. min.
Grac. maj.

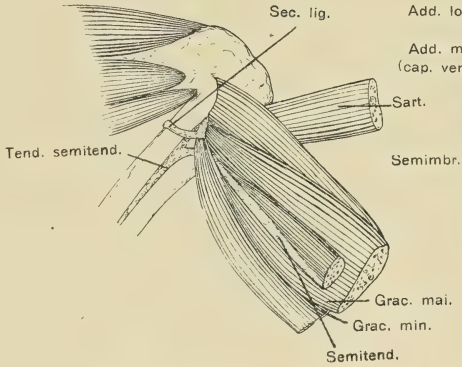
1


Crur.
Sart.
Semitend.
Grac. maj.
Grac. min.
Sec. lig.
Tend. semitend.

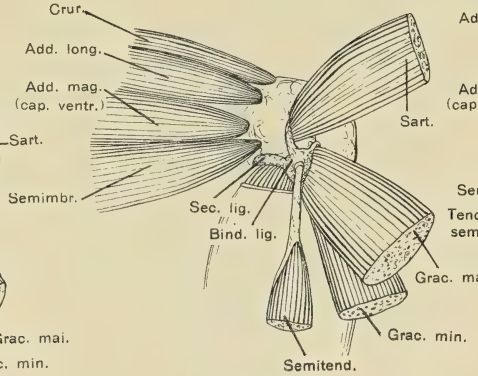
2


Sec. lig.
Tend. semitend.
Sart.
Grac. maj.
Grac. min.
Semitend.

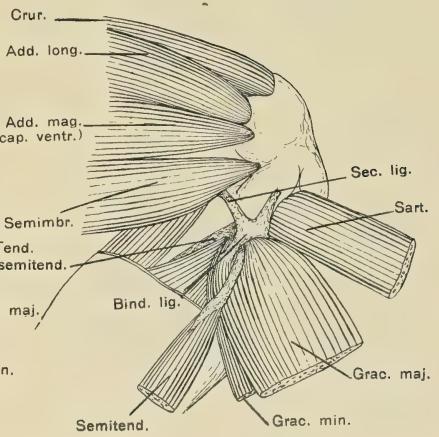
3


Sec. lig.
Sart.
Tend. semitend.
Grac. mai.
Grac. min.
Semitend.

4


Crur.
Add. long.
Add. mag.
(cap. ventr.)
Sart.
Semimbr.
Sec. lig.
Bind. lig.
Grac. maj.
Grac. min.
Semitend.

5


Crur.
Add. long.
Add. mag.
(cap. ventr.)
Sec. lig.
Sart.
Semimbr.
Tend.
semitend.
Bind. lig.
Grac. maj.
Semitend.
Grac. min.

6

Plate XVI

Distal tendons of the thigh; Figs. 1, 2, and 3 illustrating the ranid type of complex; Figs. 4, 5, and 6 special modification of simpler types.

Fig. 1. *Microhyla pulchra* (Hallowell).

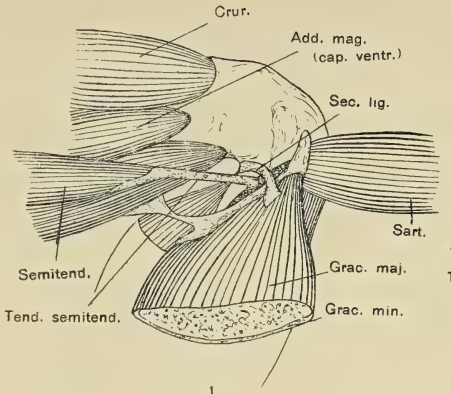
Fig. 2. *Astylosternus robustus* (Boulenger).

Fig. 3. *Rana cyanophlyctis* Schneider.

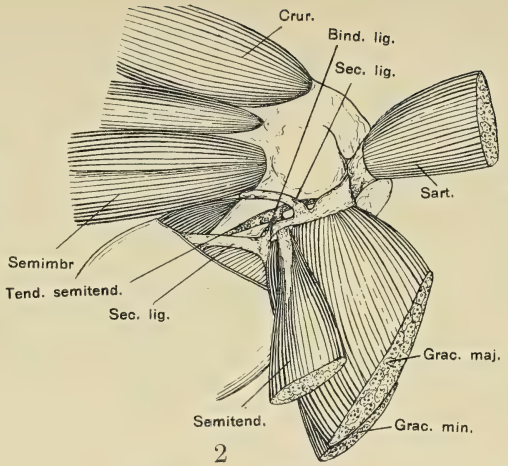
Fig. 4. *Xenopus tropicalis* (Gray).

Fig. 5. *Xenopus mülleri* (Peters).

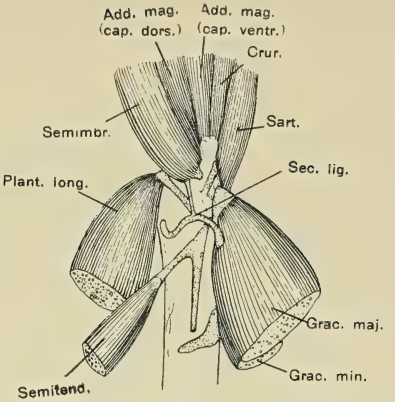
Fig. 6. *Rhinophrynus dorsalis* Duméril and Bibron.


Crur.
Add. mag.
(cap. ventr.)
Sec. lig.
Sart.
Semitend.
Tend. semitend.
Grac. maj.
Grac. min.

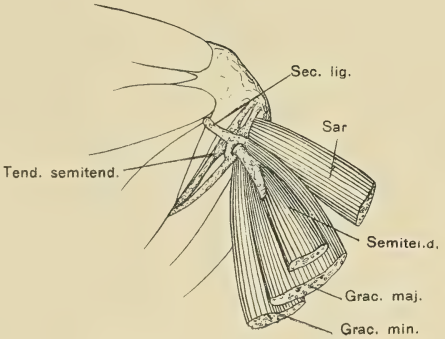
1


Crur.
Bind. lig.
Sec. lig.
Sart.
Semimbr
Tend. semitend.
Sec. lig.
Grac. maj.
Semitend.
Grac. min.

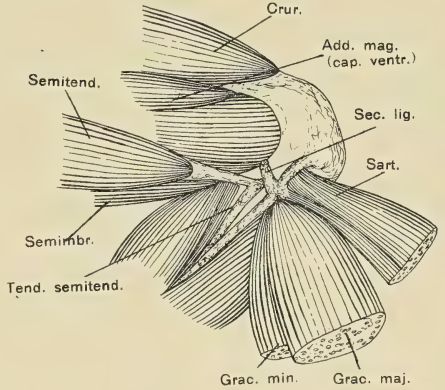
2


Add. mag.
(cap. dors.)
Add. mag.
(cap. ventr.)
Crur.
Semimbr.
Sart.
Plant. long.
Sec. lig.
Grac. maj.
Grac. min.
Semitend.

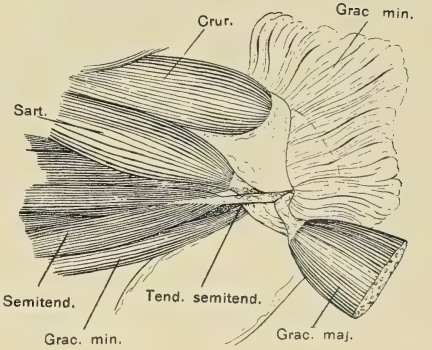
3


Sec. lig.
Sar
Tend. semitend.
Semitend.
Grac. maj.
Grac. min.

4


Crur.
Add. mag.
(cap. ventr.)
Semitend.
Sec. lig.
Sart.
Semimbr.
Tend. semitend.
Grac. min.
Grac. maj.

5


Crur.
Grac min.
Sart.
Semitend.
Tend. semitend.
Grac. min.
Grac. maj.

6

Plate XVII

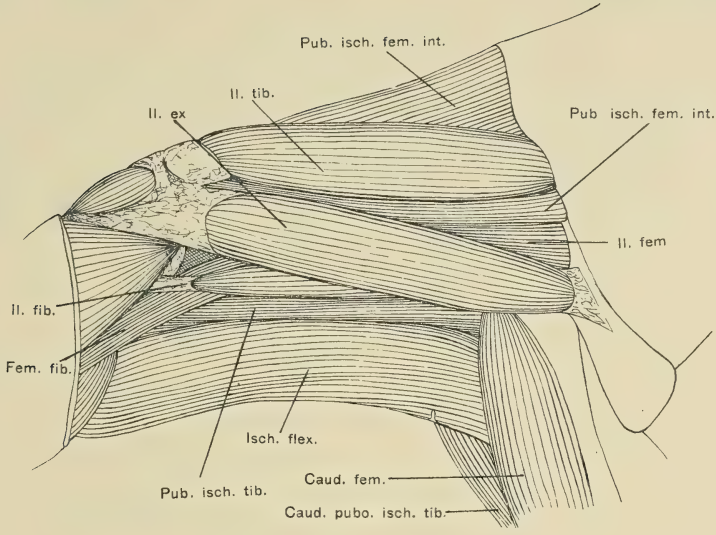
Thigh muscles of urodeles compared with those of *Ascaphus*.

Fig. 1. *Cryptobranchus alleganiensis* (Daudin).

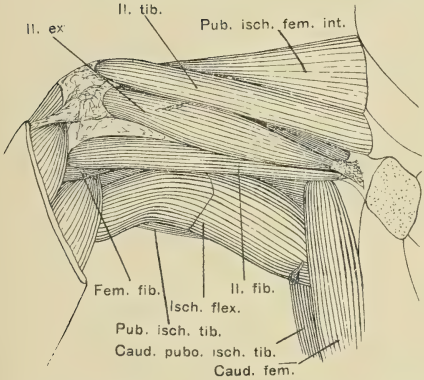
Figs. 2 and 3. Dorsal and ventral aspect of the thigh of *Rhyacotriton olympicus* (Gaige).

Figs. 4 and 5. Outline drawings of the dorsal and ventral surface of the thigh of *Ascaphus*. The homologies of the muscles are indicated in brackets. Compare with the table of homologies, Table 1, and with the detailed figures of the thigh of *Ascaphus* (Pl. VI).

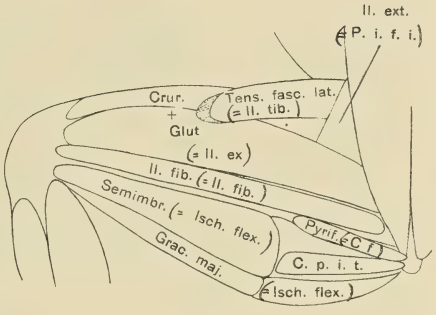
1


Pub. isch. fem. int.
Il. tib.
Il. ex
Pub isch. fem. int.
Il. fem
Il. fib.
Fem. fib.
Isch. flex.
Pub. isch. tib.
Caud. fem.
Caud. pubo. isch. tib.

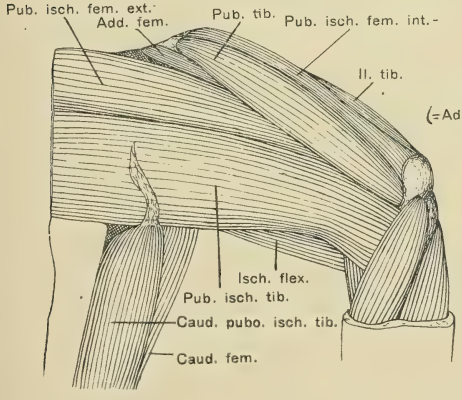
2


Il. tib.
Il. ex
Pub. isch. fem. int.
Fem. fib.
Isch. flex.
Il. fib.
Pub. isch. tib.
Caud. pubo. isch. tib.
Caud. fem.

4


Il. ext.
(= P. i. f. i.)
Crur.
+
Glut
(= Il. ex)
Tens. fasc. lat.
(= Il. tib.)
Il. fib. (= Il. fib.)
Semimbr. (= Isch. flex.)
Grac. maj.
Pyrif. & C. f.
C. p. i. t.
(= Isch. flex.)

3


Pub. isch. fem. ext.
Add. fem.
Pub. tib.
Pub. isch. fem. int.
Il. tib.
Isch. flex.
Pub. isch. tib.
Caud. pubo. isch. tib.
Caud. fem.

5

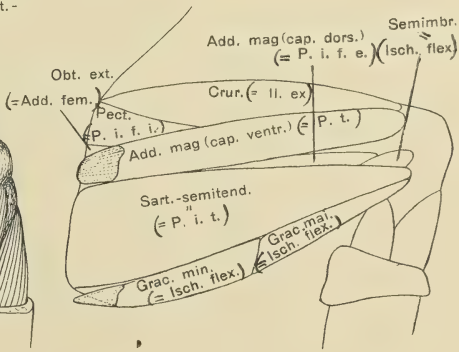

Add. mag (cap. dors.)
(= P. i. f. e.)
Semimbr.
=
(Isch. flex)
Obt. ext.
(= Add. fem.)
Crur. (= Il. ex)
Pect.
(= P. i. f. i.)
Add. mag (cap. ventr.)
(= P. t.)
Sart.-semitend.
(= P. i. t.)
Grac. maj.
(= Isch. flex.)
Grac. min.
(= Isch. flex.)

Plate XVIII

Detailed innervation of certain superficial muscles in the Salientia as shown by cleared acetic-osmic preparation.

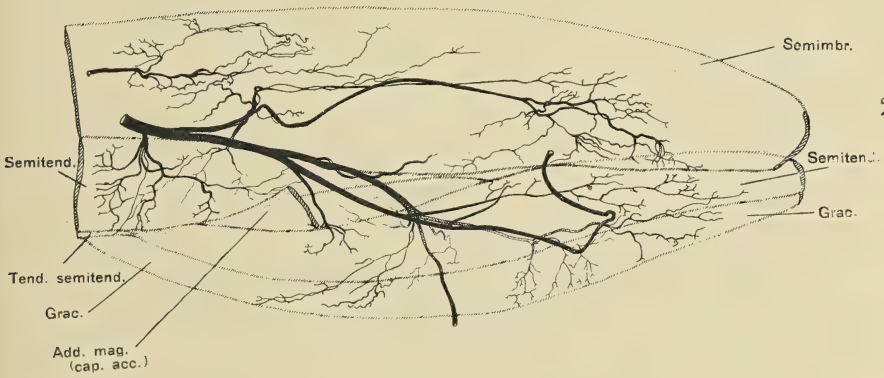
Fig. 1. Adductor longus and sartorius in *Acris gryllus* (Le Conte) viewed from ventral (outer) aspect. It will be noted that the innervation of these two muscles is entirely distinct.

Fig. 2. Semimembranosus, semitendinosus, and gracilis major and minor of *Acris gryllus* (Le Conte); viewed from femoral side.

Fig. 3. Same in *Ascaphus truei* Stejneger. In this form the sartorius forms part of the semitendinosus. Thus this figure should be compared with both Figs. 1 and 2.

Add. long.
Sart.

1


Semimbr.
Semitend.
Semiten.
Grac.
Tend. semitend.
Grac.
Add. mag.
(cap. acc.)

2

Semimbr.
Grac.
Semitend.
Sart.-semitend.

3

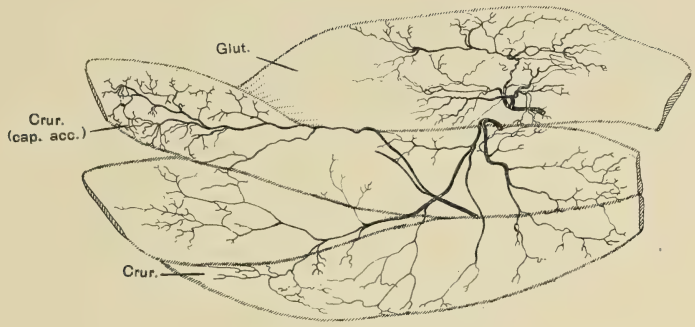
Plate XIX

Detailed innervation of certain thigh muscles in *Acris gryllus* (Le Conte), as shown by cleared acetic-osmic preparations.

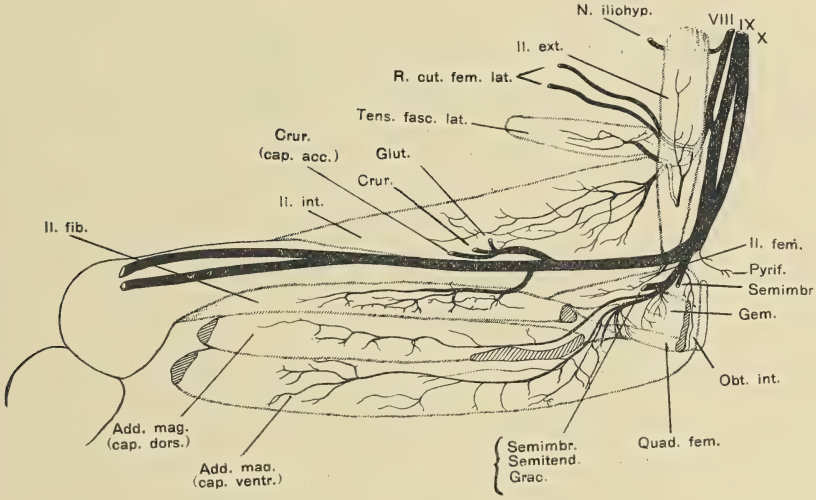
Fig. 1. Glutæus and cruralis, femoral aspect.

Fig. 2. Deep muscles of the thigh together with their innervation, dorsal view. Most of the muscles have been cut near their attachments in order to bring the nerves into the same plane.

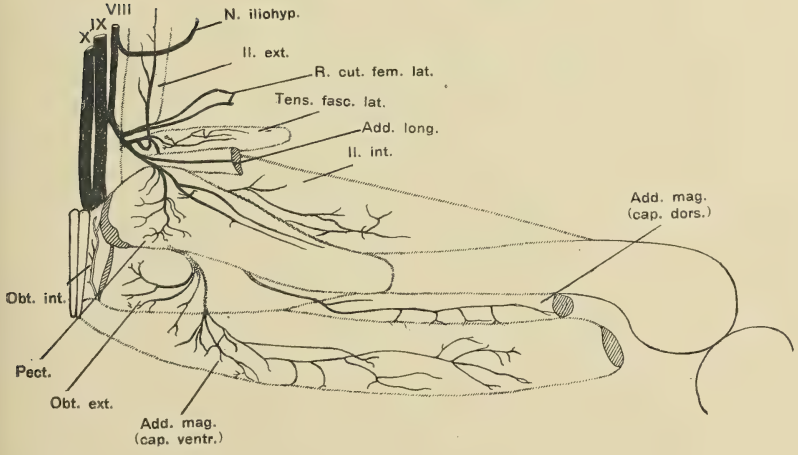
Fig. 3. Ventral aspect of the thigh, showing the deep muscles and their innervations.


Glut.
Crur.
(cap. acc.)
Crur.

1


N. iliohyp.
VIII
IX
X
Il. ext.
R. cut. fem. lat.
Tens. fasc. lat.
Crur.
(cap. acc.)
Glut.
Crur.
Il. int.
Il. fib.
Il. fem.
Pyrif.
Semimbr
Gem.
Obt. int.
Add. mag.
(cap. dors.)
Add. mag.
(cap. ventr.)
Semimbr.
Semitend.
Grac.
Quad. fem.

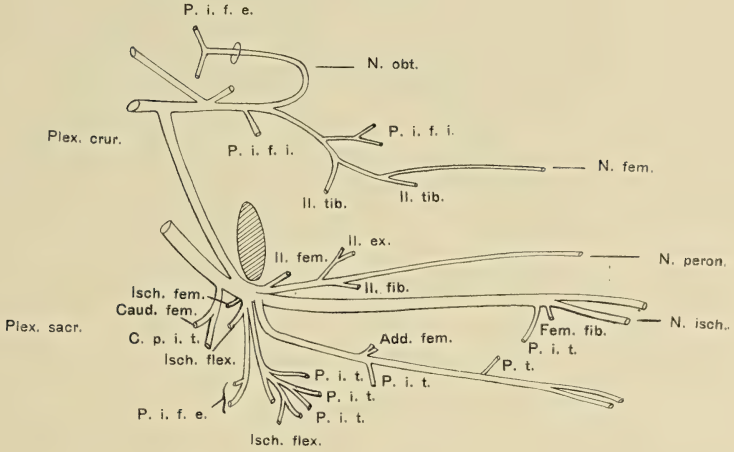
2


VIII
IX
X
N. iliohyp.
Il. ext.
R. cut. fem. lat.
Tens. fasc. lat.
Add. long.
Il. int.
Add. mag.
(cap. dors.)
Obt. int.
Pect.
Obt. ext.
Add. mag.
(cap. ventr.)

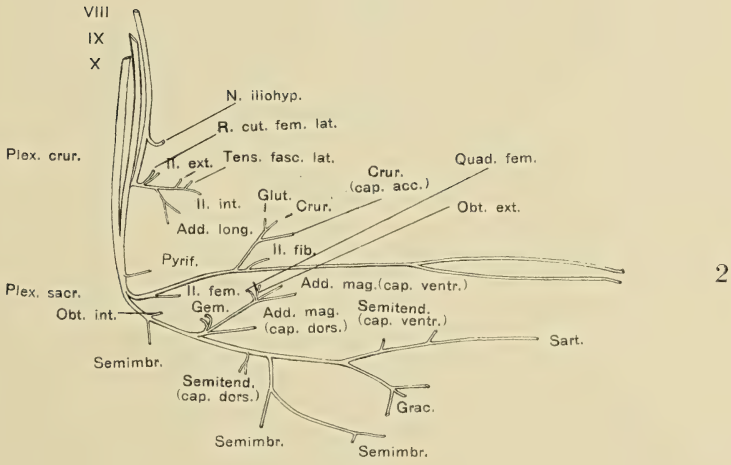
3

Plate XX

Comparison of the main nerve trunks in a urodele and frog.
Fig. 1. *Desmognathus fuscus* (Rafinesque).
Fig. 2. *Acris gryllus* (Le Conte).


P. i. f. e.
N. obt.
Plex. crur.
P. i. f. i.
P. i. f. i.
N. fem.
Il. tib.
Il. tib.
Il. ex.
Il. fem.
N. peron.
Il. fib.
Isch. fem.
Caud. fem.
Plex. sacr.
C. p. i. t.
Isch. flex.
Add. fem.
Fem. fib.
N. isch.
P. i. t.
P. t.
P. i. t.
P. i. t.
P. i. t.
P. i. f. e.
P. i. t.
Isch. flex.

1


VIII
IX
X
N. iliohyp.
R. cut. fem. lat.
Plex. crur.
Il. ext.
Tens. fasc. lat.
Quad. fem.
Crur. (cap. acc.)
Glut.
Il. int.
Crur.
Obt. ext.
Add. long.
Pyrif.
Il. fib.
Plex. sacr.
Il. fem.
Add. mag. (cap. ventr.)
Gem.
Obt. int.
Add. mag. (cap. dors.)
Semitend. (cap. ventr.)
Sart.
Semimbr.
Semitend. (cap. dors.)
Grac.
Semimbr.
Semimbr.

2

Plate XXI

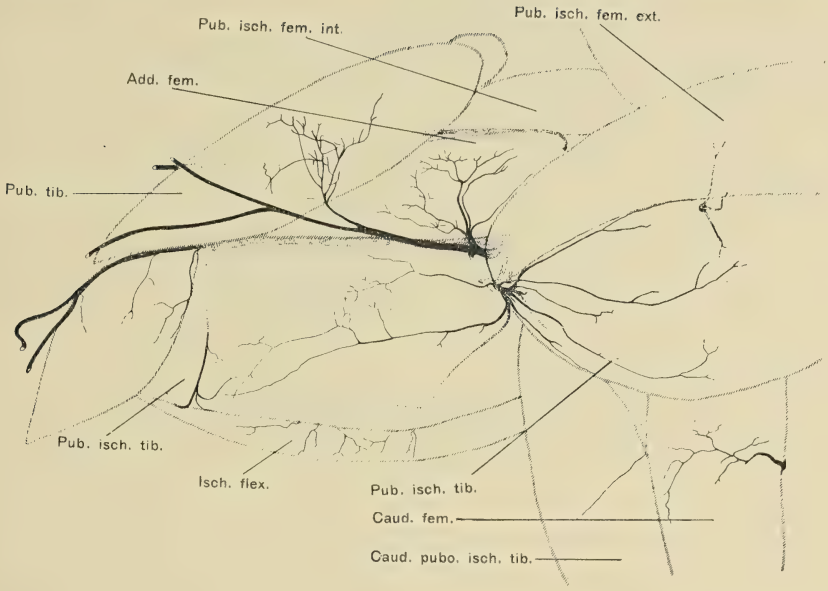
Detailed innervations of the thigh muscles of *Desmognathus fuscus* (Rafinesque) as shown by cleared acetic-osmic preparations.

Fig. 1. Innervation of the superficial muscles on the ventral surface.

Fig. 2. Innervation of the iliotibialis, ilio-extensorius and iliofibularis.

Fig. 3. Innervation of the pubotibialis.

The figures not drawn to the same scale.


Pub. isch. fem. int.
Pub. isch. fem. ext.
Add. fem.
Pub. tib.
Pub. isch. tib.
Isch. flex.
Pub. isch. tib.
Caud. fem.
Caud. pubo. isch. tib.

1

Il. tib.
Il. ex.
Il. fib.

2

Pub. tib.

3

Plate XXII

Pelvis with its muscle areas in a urodele and a frog, with inferred areas in *Eryops*.
Oblique hatch muscle areas on outer aspect of pelvis.
Even stipple muscle areas on inner aspect of pelvis.
Irregular stipple cartilage.
Outline bone.

Fig. 1. *Rhyacotriton olympicus* (Gaige).
Fig. 2. *Eryops macrocephalus* Cope.
Fig. 3. *Ascaphus truei* Stejneger, female.

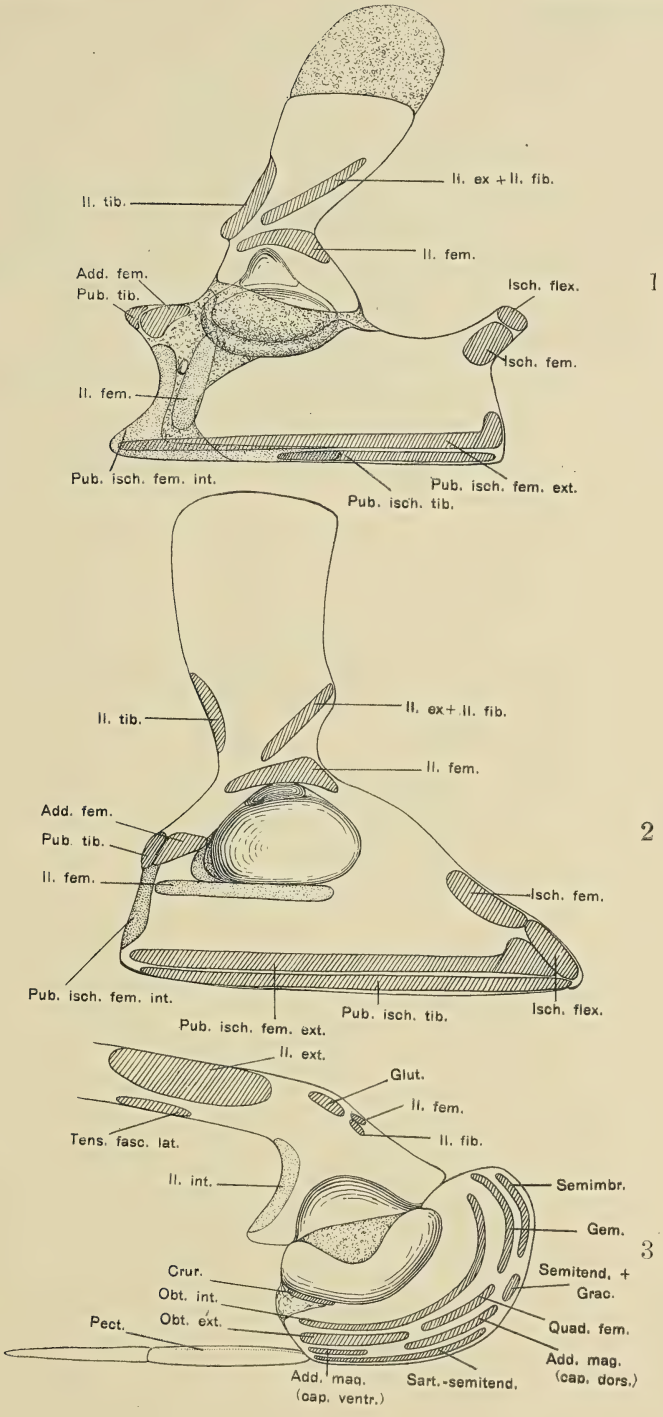

Il. ex + Il. fib.
Il. tib.
Il. fem.
Add. fem.
Pub. tib.
Isch. flex.
Isch. fem.
Il. fem.
Pub. isch. fem. int.
Pub. isch. tib.
Pub. isch. fem. ext.
1
Il. tib.
Il. ex+ Il. fib.
Il. fem.
Add. fem.
Pub. tib.
Il. fem.
Isch. fem.
Pub. isch. fem. int.
Pub. isch. fem. ext.
Pub. isch. tib.
Isch. flex.
2
Il. ext.
Glut.
Il. fem.
Il. fib.
Tens. fasc. lat.
Il. int.
Semimbr.
Gem.
Crur.
Obt. int.
Obt. ext.
Semitend. +
Grac.
Pect.
Quad. fem.
Add. mag.
(cap. dors.)
Add. mag.
(cap. ventr.)
Sart.-semitend.
3

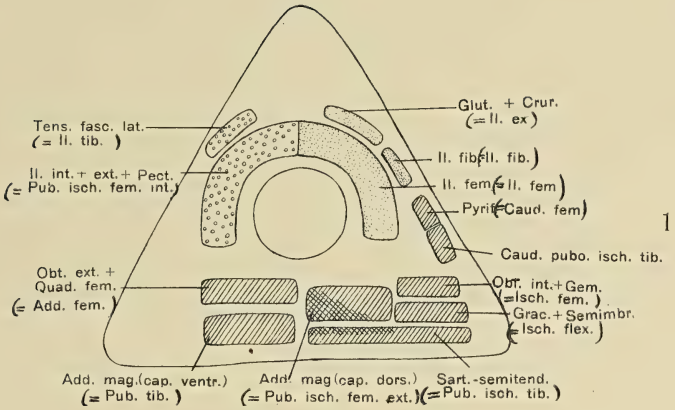
Plate XXIII

Diagrams to illustrate the homologies of urodele and frog thigh muscles. Schematized cross-sections of the thigh at a point near the acetabulum.

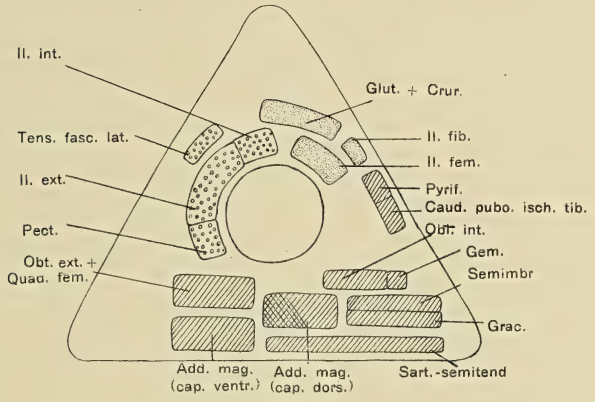
Fig. 1. Generalized urodele.

Fig. 2. Hypothetical intermediate type.

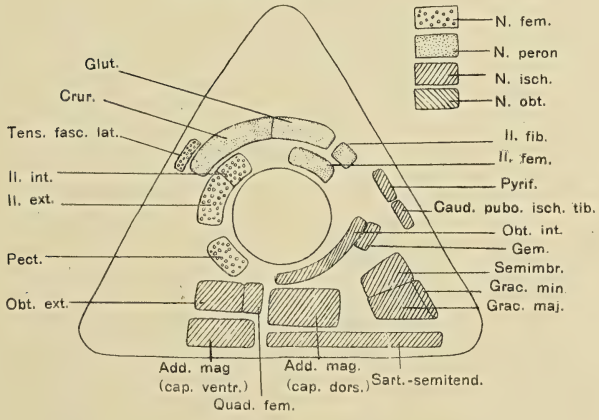
Fig. 3. Generalized salientian.


Glut. + Crur.
(= Il. ex)
Tens. fasc. lat.
(= Il. tib.)
Il. fib. (Il. fib.)
Il. int. + ext. + Pect.
(= Pub. isch. fem. int.)
Il. fem. (= Il. fem)
Pyrif. (= Caud. fem)
Caud. pubo. isch. tib.
Obt. ext. +
Quad. fem.
(= Add. fem.)
Obt. int. + Gem.
(= Isch. fem.)
Grac. + Semimbr.
(= Isch. flex.)
Add. mag. (cap. ventr.)
(= Pub. tib.)
Add. mag. (cap. dors.)
(= Pub. isch. fem. ext.)
Sart.-semitend.
(= Pub. isch. tib.)

1


Il. int.
Glut. + Crur.
Tens. fasc. lat.
Il. fib.
Il. fem.
Il. ext.
Pyrif.
Caud. pubo. isch. tib.
Pect.
Obt. int.
Gem.
Obt. ext. +
Quad. fem.
Semimbr
Grac.
Add. mag.
(cap. ventr.)
Add. mag.
(cap. dors.)
Sart.-semitend

2


N. fem.
N. peron
N. isch.
N. obt.
Glut.
Crur.
Tens. fasc. lat.
Il. fib.
Il. fem.
Il. int.
Il. ext.
Pyrif.
Caud. pubo. isch. tib.
Obt. int.
Pect.
Gem.
Semimbr.
Grac. min.
Obt. ext.
Grac. maj.
Add. mag
(cap. ventr.)
Add. mag.
(cap. dors.)
Sart.-semitend.
Quad. fem.

3

Article II.—A LIST OF NEW CRYSTAL FORMS OF MINERALS

By Herbert P. Whitlock

The present list of new crystal forms is an extension of a list published in 1910 by the writer.[1] This former compilation listed the crystal forms described subsequent to the publication of Goldschmidt's 'Index' (1891), the entries being arranged by authors under each species. This arrangement involved several disadvantages in as much as the sequence of forms was necessarily broken and the availability for ready reference seriously impaired. The present compilation aims to correct these defects, to include additional data, and, while embracing the former work, to extend it to cover the great mass of new material which has resulted from crystallographic investigation during the past decade.

That such a systematic compendium of new crystal forms should prove of value is evidenced by the fact that the writer has, in the course of preparing the present list, frequently encountered crystal forms which were given by their respective authors as new, but which have upon investigation proved to have been previously cited by other authorities. The literature of crystallography has become so complex and voluminous that it is now obviously extremely difficult for an investigator to be sure as to the status of an apparently new form without long and arduous search. It is the purpose of the present list to supply in a convenient form an answer to this difficulty.

The scope of the work involves the results of the thirty years from 1890 to 1920, references prior to the former date being available in Goldschmidt's 'Index der Krystallformen der Mineralien.' Although frequent use has been made of the abstracts published in the Neues Jahrbuch der Mineralien and in the appendices of Dana's 'System of Mineralogy,' in most instances the work has been checked by direct reference to the original articles. Care has also been taken to obtain accurate data regarding the localities cited, which were, in many instances, vague and, in some cases, misleading. Where new orientations of a species have been proposed and authoratively accepted, forms previously cited have been transposed to correspond with the new axial elements. In such cases the axial elements used are given at the head of the species. In a number of instances, particularly where species rich in forms are involved, articles have been published which contain bibli-

[1]H. P. Whitlock. 1910. 'A List of New Crystal Forms of Minerals.' School of Mines Quarterly, XXXI, p. 320 and XXXII, p. 51.

ographies, lists of previously described forms, and other crystallographic information of exceptional value relating to the species. These have been designated with a star in the list of numbered references.

Under each listed form is given

(1) The letter by which it was designated in the original paper, or where the letter system has been revised, the letter assigned to it in such revision;

(2) The Goldschmidt indices, as given in the second column of his 'Krystallographische Winkeltabellen';

(3) The Miller indices;

(4) The locality from which the crystals furnishing the form was derived; and

(5) A number corresponding to an entry in a list of references placed at the end of each species, giving the author and the publication containing the original description.

In attempting a compilation of this scope, the writer is keenly conscious of the possibility of omissions and errors, and will gratefully welcome additions and corrections.

ACMITE-AEGIRITE

V	11∞	11.1.0	Eker, Norway	1
χ	5∞	510	" "	1
f	3∞	310	" "	1
L	$\frac{7}{3}\infty$	730	" "	1
W	$\frac{16}{15}\infty$	16.15.0	" "	1
t	$\infty 3$	130	Libby, Mont.	6+7
Λ	$\infty 7$	170		7
r	$0\frac{5}{3}$	053	Långban, Sweden (Urbanite)	3
H	$-\frac{3}{2}0$	$\bar{3}02$	Eker, Norway	1
s	-1	$\bar{1}11$	" "	1
v	2	221	" "	1
w	3	331	Quincy, Mass.	5
	5	551	" "	5
C	6	661		2
Ω	-8	$\bar{8}81$	Eker, Norway	1
O	-6	$\bar{6}61$	" "	1
π	-5	$\bar{5}51$	" "	1
λ	-3	$\bar{3}31$	" "	1

	—2	$\bar{2}21$	Kororsuak, Greenland	4
	$-\frac{1}{2}$	$\bar{1}12$	Quincy, Mass.	5
d	13	131	" "	5
Q	16	161	Eker, Norway	1
K	—19	$\bar{1}91$	" "	1
Λ	45	451	" "	1
Δ	$\frac{5}{2}\frac{9}{2}$	592	" "	1
X	46	461	Igaliko, Greenland	2
𝔅	57	571	" "	2
y	$-\frac{3}{2}\frac{1}{4}$	$\bar{6}14$	Långban, Sweden (Urbanite)	3
k	$-\frac{3}{2}\frac{1}{2}$	$\bar{3}12$	Eker, Norway	1
z	$-\frac{4}{3}\frac{10}{3}$	$\bar{4}.10.3$	" "	1

1.—W. C. Brögger, 1890, Zeitschr. f. Kryst., XVI, p. 658.
2.—G. Flink, 1894, Zeitschr. f. Kryst., XXIII, p. 360.
3.—Hj. Sjögren, 1894, Geol. Fören. Förh., XIV, p. 251.
4.—O. B. Böggild, 1905, Min. Grönland, p. 379.
5.—C. Palache and C. H. Warren, 1911, Amer. Journ. Sci., XXXI, p. 550.
6.—E. S. Larsen and W. F. Hunt, 1913, Amer. Journ. Sci., XXXIV, p. 289.
7.—R. Doht and C. Hlawatsch, 1913, Verh. d. k. k. geol. Reich., Wien, p. 79.

Adelite

$a:b:c = 1.0989:1:1.5642 \quad \beta = 73° 15'$

a	$\infty 0$	100	Nordmark—Långban, Sweden	1
c	0	001	" " "	1
m	∞	110	" " "	1
f	01	011	" " "	1
d	—2	$\bar{2}21$	" " "	1

1.—Hj. Sjögren, 1891, Geol. Fören. Förh., XIII, p. 781.

Adamite

f	$\frac{1}{3}0$	103	Island of Thasos, Greece	2
e	$\frac{2}{5}0$	205	" " " "	2
	$\frac{6}{7}0$	607	Monte Valerio, Italy	1
	12	121	" " "	1
p	$\frac{1}{3}\frac{2}{3}$	123	Island of Thasos, Greece	2

1.—Aloisi, 1909, Riv. Min. Ital., XXXIX, p. 58.
2.—V. Rosicky, 1908, Abh. d. böhm. Akad., XIII, No. 28.

Alamosite

$a:b:c = 1.375:1:0.924 \quad \beta = 84° 10'$

c	0	001	Alamos, Mexico	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
m	∞	110	" "	1
v	10	101	" "	1
g	01	011	" "	1
p	—12	$\bar{1}21$	" "	1
r	12	121	" "	1

1.—C. Palache and H. E. Merwin, 1909, Amer. Journ. Sci., XXVII, p. 399.

Albite

$a:b:c = 0.6367:1:0.5593 \quad \alpha = 94° 15' \quad \beta = 116° 37' \quad \gamma = 87° 41'$ (2)

K	$\frac{3}{5}\infty$	350	Greenland	3
Z	$\frac{1}{2}\infty$	120	Haddam Neck, Conn.	1
ϑ	$0\bar{4}$	$0\bar{4}1$	Greenland	3
Ξ	$0\bar{5}$	$0\bar{5}1$?	"	3
Γ	$\frac{1}{3}\ \frac{1}{3}$	$\bar{1}13$	"	3
Λ	$\frac{3}{2}\ \frac{3}{2}$	$\bar{3}32$	"	3
φ	$\bar{2}1$	$\bar{2}11$	"	3
Υ	$\bar{3}1$	$\bar{3}11$	Haddam Neck, Conn.	1
Θ	$\bar{1}\bar{3}$	$\bar{1}\bar{3}1$	San Benito, Calif.	4
	$\bar{1}3$	$1\bar{3}\bar{1}$		5
ξ	$\bar{1}5$	$\bar{1}51$	Greenland	
Q	$\bar{1}\frac{5}{2}$	$\bar{1}\bar{5}2$	"	
	$\frac{1}{2}\frac{9}{2}$	$\bar{1}92$		
χ	$\bar{2}4$	$\bar{2}41$	Haddam Neck, Conn.	1
X	$\bar{2}9$	$\bar{2}91$?	Greenland	3
ω	$\bar{3}3\frac{1}{2}$	$\bar{3}12$	"	3

1.—H. Bowman, 1902, Min. Mag., XIII, p. 115.
2.—G. Melczer, 1906, Zeitschr. f. Kryst., XL, p. 571.
*3.—C. Dreyer and V. Goldschmidt, 1907, Medd. om. Grönland, p. 34.
4.—G. D. Lauterback, 1909, Univ. Calif. Pub., V, p. 331.
5.—L. Iwanow, Abh. d. Ges. z. Erforschung Wolhyniens, p. 7.

Allcharite

$a:b:c = 0.9284:1:0.6080$

b	0∞	010	Allchar, Macedonia	1
m	∞	110	" "	1

n	2∞	210	Allchar, Macedonia	1
u	01	011	" "	1
z	10	101	" "	1
p	1	111	" "	1

1.—B. Ježek, 1912, Zeitschr. f. Kryst., LI, p. 275.

Altaite

β	$\frac{3}{2}1$	322	Tuolumne Co., Calif.	1

1.—A. S. Eakle, 1903, Bull. Geol. Univ. Calif., XIII, p. 279.

Amalgam

t	54	541		1

1.—H. Steinmetz and B. Gossner, 1915, Zeitschr. f. Kryst., LV, p. 156.

Analcite

	$\frac{3}{2}$	332	Renfrewshire, Scotland	1
z	$\frac{5}{3}$ $\frac{4}{3}$	543	" "	1
t	42	421	" "	1

1.—M. F. Heddle, 1897, Trans. Edin. Geol. Soc., VII, p. 241.

Anapäite

a: b: c = 0.7069:1:0.8778 $\alpha = 97° 12'$ $\beta = 95° 17'$ $\gamma = 70° 11'$ (2)

c	0	001	Anapa, Kuban, Russ.	1
a	∞0	100	" " "	1
b	0∞	010		2
m	—∞	$1\bar{1}0$	Anapa, Kuban, Russ.	1
N	+10	101		2
s	—10	$\bar{1}01$		2
q	$+0\frac{1}{2}$	012		2
o′	+1	111		2
o	$\bar{1}\bar{1}$	$\bar{1}\bar{1}1$	Anapa, Kuban, Russ.	1

1.—A. Sachs, 1902, Sitzungber. d. K. Akad. d. Wiss. Berlin, p. 18.
2.—S. Popov, 1910, Mus. Geol. Pierre le Grand. Petrograd, IV, p. 99.

Ancylite

a: b: c = 0.916:1:0.9174

d	10	101	Narsarsuk, Greenland	1
e	01	011	" "	1

1.—G. Flink, 1899, Medd. om. Grönland, XIV, p. 235.

Andalusite

i	$\frac{3}{2}\infty$	320	Pitzthal, Tyrol	1
t	$0\frac{1}{3}$	013	" "	1
v	$0\frac{5}{4}$	054	" "	1
x	$\frac{1}{2}$	112	" "	1

1.—P. E. Haefell, 1894, Zeitschr. f. Kryst., XXIII, p. 551.

Andesine

	$\frac{1}{2}\infty$	120	Siebengebirge	1

1.—K. Busz, 1898, Neues Jahrb. f. Min., I, p. 36.

Andorite

a: b: c = 0.6772:1:0.4458 Brögger (1)

c	0	001	Ororo, Bolivia	2
a	$\infty 0$	100	" "	2
b	0∞	010	" "	2
φ	6∞	610	" "	2
Ψ	5∞	510	" "	2
n	2∞	210	" "	2
o	$\frac{3}{2}\infty$	320	" "	2
i	$\frac{4}{3}\infty$	430	Felsöbánya, Hungary	2
m	∞	110	Ororo, Bolivia	2
l	$\infty\frac{3}{2}$	230	" "	2
k	$\infty 2$	120	" "	2
g	$\infty\frac{5}{2}$	250	" "	1
u	$\infty 3$	130	Felsöbánya, Hungary	2
w	$0\frac{3}{5}$	035	Ororo, Bolivia	3
x	01	011	" "	2
v	$0\frac{4}{3}$	043	" "	2
π	$0\frac{3}{2}$	032	" "	2
γ	02	021	" "	2
y	03	031	" "	2
n	04	041	" "	3
t	09	091	Felsöbánya, Hungary	2
h	$\frac{1}{2}0$	102	Ororo, Bolivia	2
Θ	$\frac{2}{5}0$	305	" "	2
σ	$\frac{2}{3}0$	203	" "	2
κ	$\frac{4}{5}0$	405	" "	2

f	10	101	Ororo, Bolivia	2
e	$\frac{3}{2}0$	302	" "	2
χ	30	301	" "	2
μ	$\frac{9}{2}0$	902	" "	2
d	60	601	" "	1
v	$\frac{1}{2}$	112	" "	2
χ	$\frac{2}{3}$	223	" "	2
p	1	111	" "	2
z	$\frac{3}{2}$	332	" "	2
q	2	221	" "	2
ρ	3	331	" "	2
B	4	441	" "	3
s	21	211	" "	2
C	$\frac{2}{3}\ \frac{4}{3}$	243	" "	3
δ	$\frac{3}{4}\ \frac{3}{2}$	364	" "	2
r	12	121	" "	2
ϵ	$\frac{3}{2}3$	362	" "	2
D	24	241	" "	3
ω	$\frac{1}{2}\ \frac{3}{2}$	132	" "	2
β	13	131	" "	2
E	26	261	" "	3
α	$\frac{1}{2}3$	162	" "	2
ζ	$\frac{2}{7}3$	2.21.7	" "	2
ξ	$\frac{2}{2}\ \frac{1}{2}$	312	" "	3
A	32	321	" "	3

1.—W. C. Brögger, 1893, Zeitschr. f. Kryst., XXI, p. 193.
2.—G. F. Prior and L. J. Spencer, 1897, Min. Mag., XI, p. 286.
3.—L. J. Spencer, 1907, Min. Mag., XIV, p. 308.

Anglesite

C	$\frac{1}{7}^{0}\ \infty$	10.7.0	Tintic Dist., Utah	3
Ω	$\frac{5}{4}\ \infty$	540	Monte Poni, Sardinia	4
	$\infty\frac{5}{4}$	450	Sardinia and Tintic Dist., Utah	10+11
	$0\frac{1}{6}$	016	Altai Mts., Siberia	1
j	$0\frac{1}{5}$	045	Siegen, Ger.	6
D	$\frac{1}{1\,6}0$	1.0.16	Tintic Dist., Utah	3
$\mathfrak{s}$	$\frac{1}{5}0$	105	Siegen and Cerro Gordo, Mex.	6+7
Y	$\frac{2}{9}0$	209	Tintic Dist., Utah	3
	$\frac{2}{2}^{1}0$	21.0.2	Monte Poni, Sardinia	8
$\mathfrak{v}$	$\frac{2}{1}\frac{5}{7}$	25.25.17	Tintic Dist., Utah	3

$\mathfrak{v}$.	$\frac{1}{9}\frac{4}{}$	14.14.9	Tintic Dist., Utah	3
$\mathfrak{v}$:	$\frac{1}{1}\frac{5}{1}$	15.15.11	" " "	3
D	$\frac{2}{5}1$	255	Source unknown	2
	$\frac{3}{4}1$	344	Siegen and Sardinia	6+9
$\mathfrak{n}$	$\frac{1}{5}\frac{2}{5}$	125	Monte Poni, Sardinia	4
Σ	$\frac{1}{7}\frac{2}{7}$	127	" " "	4
Ξ	$\frac{3}{4}\frac{7}{4}$	374	Siegen, Ger.	6
σ	$\frac{1}{2}\frac{4}{3}$	386	" "	6
$\mathfrak{U}$	$\frac{3}{2}\frac{5}{2}$	352	" "	6
ϑ	$\frac{1}{2}\frac{1}{3}$	326	Schwartzwald, Ger.	9
X	$\frac{1}{4}\frac{1}{3}$	3.4.12?	Broken Hill, N. S. W.	5
v	$\frac{5}{8}\frac{9}{8}$	598?	" " "	5
$\mathfrak{w}$	23	231	Siegen, Ger.	6
$\mathfrak{z}$	$\frac{8}{3}\frac{1}{3}\frac{1}{}$	8.11.3	" "	6
$\mathfrak{v}$	34	341	" "	6
v	9.12	9.12.1	Tintic Dist., Utah	3
$\mathfrak{n}$	45	451	Siegen, Ger.	6
Φ	$\frac{7}{4}\frac{1}{4}\frac{1}{}$	7.11.4	" "	6
	$\frac{2}{2}\frac{2}{7}\frac{8}{7}$	2.28.27	Sardinia	10
	$\frac{1}{1}\frac{1}{8}\frac{3}{8}$	1.13.18	"	10
Y	$\frac{1}{7}\frac{8}{7}$	187?	Broken Hill, N. S. W.	5
	$\frac{2}{7}\frac{1}{7}\frac{5}{}$	2.15.7	Sardinia	10
	$\frac{2}{5}\frac{9}{10}$	4.9.10	"	10
	$\frac{1}{10}\frac{1}{5}$	1.2.10	"	10
	$\frac{6}{165}\cdot\frac{7}{165}$	6.7.165	"	10
	$\frac{5}{6}\frac{2}{3}$	546	"	10
	$\frac{1}{19}\frac{5}{19}\frac{8}{}$	15.8.19	"	10
	$\frac{3}{5}\frac{1}{5}$	315	"	10
	$\frac{9}{16}\frac{1}{8}$	9.2.16	"	10
	$\frac{6}{11}\frac{1}{11}$	6.1.11	"	10
R	$\frac{1}{13}\frac{1}{12}$	12.13.156	Tintic Dist., Utah	11
Φ	$\frac{7}{4}\frac{1}{4}\frac{1}{}$	7.11.4	Siegen, Ger.	6

1.—P. Jeremejew, 1892, Verh. Min. Ges., XXIX, p. 174.
2.—L. J. Spencer, 1897, Min. Mag., XI, p. 197.
3.—V. Hulyák, 1900, Term. Füz., XXIII, p. 187.
4.—P. Hermann, 1904, Zeitschr. f. Kryst., XXXIX, p. 463.
5.—C. Anderson, 1908, Rec. Austr. Mus., VII, p. 63.
6.—J. Kruse, 1909, Neues Jahrb. f. Min., B.-B., XXVII, p. 541.
7.—J. Krizo, 1909, Földt. Közlöny, XXXIX, p. 388.
8.—E. Tacconi, 1911, Rend. Inst. Lomb., XLIV, p. 986.
9.—V. Dürrfeld, 1912, Zeitschr. f. Kryst., L, p. 582.
10.—G. Cesàro, 1912, Mém. Soc. Géol. Belg., XXXIX, p. 239.
11.—E. H. Kraus and A. B. Peck, 1916, Neues Jahrb. f. Min., II, p. 17.

Anhydrite

$a:b:c = 1.1204:1:1.1195$

φ	$\frac{1}{6}0$	106	Monte Somma, Italy	2
p	$\frac{1}{5}$	115	Aussee, Styria	1

1.—F. Bascom and V. Goldschmidt, 1908, Zeitschr. f. Kryst., XLIV, p. 65.
2.—F. Zambonini, 1910, R. Accad. d. Sci. d. Napoli, p. 324.

Anorthite

G	$-\frac{4}{5}0$	$\bar{4}05$	Aranyi-Berg, Transylvania	1
F	$-\frac{2}{5}0$	$\bar{2}05$	" "	1
V	$\bar{1}3$	$\bar{1}31$	" "	1
H	42	421	" "	1
K	$\frac{\bar{2}}{3}\frac{4}{3}$	$\bar{2}43$	" "	1
L	$\frac{2}{3}\frac{\bar{4}}{3}$	$2\bar{4}3$	" "	1

1.—V. Hulyák, 1904, Zeitschr. f. Kryst., XL, p. 504.

Apatite

K	$\frac{1.0}{9}\infty$	$10.9.\bar{1}\bar{9}.0$	Epprechtstein, Bavaria	11
B	$\frac{5}{4}\infty$	$54\bar{9}0$	" "	11
l	$\frac{4}{3}\infty$	$43\bar{7}0$	Haddam Neck, Conn.	7
W	$\frac{5}{2}\infty$	$52\bar{7}0$	" " "	7
K_1	$\infty\frac{1.0}{9}$	$9.10.\bar{1}\bar{9}.0$	Epprechtstein, Bavaria	11
W_1	$\infty\frac{5}{2}$	$25\bar{7}0$	Haddam Neck, Conn.	7
P	$\frac{2}{1\,9}0$	$2.0.\bar{2}.19$	" " "	7
λ	$\frac{4}{2\,1}0$	$4.0.\bar{4}.21$	Gletsch, Switzerland	10
K	$\frac{2}{9}0$	$20\bar{2}9$	Halvorsröd, Norway	12
F	$\frac{1}{4}0$	$10\bar{1}4$	Biella, Italy	9
Q	$\frac{2}{7}0$	$20\bar{2}7$	Haddam Neck, Conn.	7
e	$\frac{7}{1\,1}0$	$7.0.\bar{7}.11$	Gellivara, Sweden	8
f	$\frac{2}{3}0$	$20\bar{2}3$	" "	8
β	$\frac{5}{7}0$	$50\bar{5}7$	Gletsch, Switzerland	10
g	$\frac{7}{9}0$	$70\bar{7}9$	Gellivara, Sweden	8
δ	$\frac{4}{5}0$	$40\bar{4}5$	Gletsch, Switzerland	10
j	$\frac{7}{8}0$	$70\bar{7}8$	Gellivara, Sweden	8
γ	$\frac{8}{9}0$	$80\bar{8}9$	Gletsch, Switzerland	10
	$\frac{8}{7}0$	$80\bar{8}7$	Ural Mts., Russia	4
L	$\frac{1\,5}{1\,3}0$	$15.0.\bar{1}\bar{5}.13$	Halvorsröd, Norway	12
O	$\frac{1.2}{5}0$	$12.0.\bar{1}\bar{2}.5$	Knappenwand	6
D	$\frac{1.3}{4}0$	$13.0.\bar{1}\bar{3}.4$	Epprechtstein, Bavaria	11

t	$\frac{1}{1\,2}$	1.1.$\bar{2}$.12	Münster, Westfalia, Ger.	2
W	$\frac{1}{9}$	11$\bar{2}$9	Halvorsröd, Norway	12
A	$\frac{1}{3}$	11$\bar{2}$3	Lake Orta, Italy	3
b	$\frac{2}{3}$	22$\bar{4}$3	St. Just, Cornwall, Eng.	1
R	$\frac{5}{3}\,\frac{2}{3}$	52$\bar{7}$3	Lake Orta, Italy	3
p	$\frac{2}{3}\,\frac{1}{6}$	41$\bar{5}$6	Ala—Tal, Piedmont, Italy	5

1.—R. H. Solly, 1887, Min. Mag., VII, p. 141.
2.—C. Vrba, 1889, Zeitschr. f. Kryst., XV, p. 449.
3.—G. Struver, 1895, Zeitschr. f. Kryst., XXIV, p. 316.
4.—P. Jeremejew, 1895, Verh. Min. Ges., XXXIII, p. 65.
5.—G. Struver, 1899, Riv. d. Min. Padua, XXII, p. 80.
6.—F. Slavíc, 1901, Abh. d. böhm. Akad., ρ. 16.
7.—H. L. Bowman, 1902, Min. Mag., XIII, p. 97.
8.—K. Zimányi, 1904, Zeitschr. f. Kryst., XXXIX, p. 508.
9.—F. Zambonini, 1905, Zeitschr. f. Kryst., XL, p. 220.
10.—K. Busz, 1906, Centralb. f. Min., p. 755.
*11.—K. Walter, 1907, Neues Jahrb. f. Min., Beil. B., XXIII, p. 581.
12.—J. Schetelig, 1913, Norks. geol. Tidsskrift, (3) II, p. 38.

Apophyllite

	$0\frac{1}{3}$	013	Seiser Alp, Italy	4
ξ	$\frac{1}{9}$	119	Kimberley, S. Africa	2
	$\frac{1}{5}$	115	Utö, Sweden	6
χ	$\frac{2}{3}$	223	Kimberley, S. Africa	2
	$\frac{1\,9}{1\,8}$	19.19.18	Sulitelma, Sweden	3
	$\frac{1\,7}{1\,6}$	17.17.16	" "	3
	$\frac{1\,5}{1\,4}$	15.15.14	" "	3
	$\frac{1\,4}{1\,3}$	14.14.13	" "	3
	$\frac{1\,3}{1\,2}$	13.13.12	" "	3
	$\frac{1\,2}{1\,1}$	12.12.11	" "	3
	$\frac{1\,1}{1\,0}$	11.11.10	Harz, Germany	1
	$\frac{1\,0}{9}$	10.10.9	Sulitelma, Sweden	3
	$\frac{9}{8}$	998	" "	3
	$\frac{7}{6}$	776	" "	3
	$\frac{6}{5}$	665	" "	3
	$\frac{5}{4}$	554	" "	3
k	$\frac{3}{2}$	332	Kimberley, S. Afrika	2
h	7	771	Bergen Hill, N. J.	5
	42	421	Utö, Sweden	6

1.—O. Luedecke, 1896, Min. d. Harzes, p. 572.
2.—J. Currie, 1897, Trans. Edin. Geol. Soc., VII, p. 252.

3.—A. Hennig, 1899, Geol. Fören. Förh., XXI, p. 391.
4.—F. Zambonini, 1901, Zeitschr. f. Kryst., XXXIV, p. 391.
5.—H. P. Whitlock, 1910, School of Mines Quar., XXXI, p. 231.
6.—G. Flink, 1906, Geol. Fören. Förh., XXVIII, p. 423.

Aragonite

	$\infty\frac{7}{5}$	570	Monte Ramazzo, Italy	2
	$\infty\frac{1\,3}{1\,1}$	11.13.0?	Val Santerna, Italy	6
	$\frac{1\,7}{1\,6}\infty$	17.16.0?	" " "	6
	$\frac{7}{6}\infty$	760	Chaudfontaine, Belgium	4
	$\frac{6}{5}\infty$	650	" "	4
	$\frac{5}{4}\infty$	540	Herrengrund, Hungary	8
	$\frac{9}{7}\infty$	970	" "	8
	$\frac{4}{3}\infty$	430	Monte Ramazzo, Italy	2
	$0\frac{1}{1\,2}$	0.1.12	Harz Mts., Germany	3
π	$0\frac{1\,9}{1\,0}$	0.19.10	Dognácska, Hungary	7
	$0\frac{7}{3}$	073	Monte Ramazzo, Italy	2
	$0\frac{2\,3}{1\,0}$	0.23.10	Kajántó, Hungary	10
	$0\frac{5}{2}$	052	Monte Ramazzo, Italy	2
	$0\frac{1\,3}{5}$	0.13.5	Kajántó, Hungary	10
	$0\frac{2\,3}{9}$	0.23.9	" "	10
	$0\frac{8}{3}$	083	" "	10
	$0\frac{1\,8}{5}$	0.18.5	" "	10
r	$0\frac{1\,1}{3}$	0.11.3	Dognácska, Hungary	7
	$0\frac{3\,7}{1\,0}$	0.37.10	Herrengrund, Hungary	8
N	$0\frac{9}{2}$	092	Dognácska, Hungary	7
	$0\frac{2\,8}{5}$	0.28.5	Kajántó, Hungary	10
	$0\frac{1\,5}{2}$	0.15.2	Framont, Alsace, France	1
K	0.17	0.17.1	Dognácska, Hungary	7
P	0.19	0.19.1	" "	7
Q	0.21	0.21.1	" "	7
R	$0.\frac{4\,5}{2}$	0.45.2	" "	7
T	0.26	0.26.1	" "	7
U	0.27	0.27.1	" "	7
Ü	0.29	0.29.1	" "	7
W	0.32	0.32.1	" "	7
X	0.35	0.35.1	" "	7
Y	0.40	0.40.1	" "	7
	0.48	0.48.1	Kajántó, "	10
e	45.45	45.45.1	Dognácska, "	7
g	21.21	21.21.1	" "	7

b	12.12	12.12.1	Dognácska, Hungary	7
J	11.11	11.11.1	Korlát, Mograd, Hungary	9
a	5	551	Dognácska, Hungary	7
	3	331	Monte Ramazzo, Italy	2
	$\frac{1}{3}1$	133	" " "	2
	$\frac{3}{2}2$	342	" " "	2
	$\frac{7}{3}\ \frac{10}{3}$	7.10.3	" " "	2
	$\frac{3}{2}\ \frac{5}{2}$	352	" " "	2
	27	271	" " "	2
	$\frac{5}{2}\ \frac{1}{2}$	512	" " "	2
	$\frac{9}{16}\ \frac{1}{8}$	9.2.16	" " "	2
	$\frac{4}{3}\ \frac{1}{3}$	413	" " "	2
	$\frac{1}{4}\ \frac{1}{6}$	3.2.12	" " "	2
	43	431	" " "	2
	24.25	24.25.1	" " "	2
	16.22	16.22.1	Val Santerna, Italy	5

1.—F. Stöber, 1894, Mitth. d. geol. Land. Els.-Lothr.
2.—G. B. Nigri, 1896, Riv. Min. Ital., XV, p. 65.
3.—L. Luedecke, 1896, Min. d. Harzes, p. 338.
4.—G. Cesáro, 1897, Mém. Ac. Sci. Belg., LIII, p. 100.
5.—L. Brugnatelli, 1898, Riv. Min. Ital., XVIII, p. 51.
6.—L. Brugnatelli, 1899, Zeitschr. f. Kryst., XXXI, p. 56.
7.—K. Zimányi, 1899, Term. Füz., XXII.
8.—G. Melczer, 1903, Zeitschr. f. Kryst., XXXVIII, p. 253.
9.—A. Liffa, 1910, Zeitschr. f. Kryst., XLVII, p. 249.
10.—E. Balogh, 1911, Mitth. Samml. Sibenb. Nat. Mus., p. 51.

Argentite

	6∞	610	Zacatecas, Mex. 1

1.—H. Ungemach, 1910, Bull. Soc. fr. Min., p. 33.

Argyradite

Isometric

d	∞	110	La Paz, Bolivia	1
o	1	111	" "	1
v	$\frac{1}{3}$	113	" "	1

1.—S. L. Penfield, 1893, Amer. Journ. Sci., XLVI, p. 107.

Arizonite

a: b: c = 1.88:1:2.3 $\beta = 55°$ (?)

0	001	Hackberry, Ariz.	1
$\infty 0$	100	" "	1
∞	110	" "	1
-10	$\bar{1}01$	" "	1
$-\frac{1}{2}$	$\bar{1}12$	" "	1

1.—C. Palmer, 1909, Amer. Journ. Sci., XXVIII, p. 353.

Arsenoferrite

Isometric Pyritohedral

a	0	100	Binnenthal, Switzerland	1
f	3∞	310	" "	1
d	∞	110	" "	1
o	1	111	" "	1

1.—H. Baumhauer, 1912, Zeitschr. f. Kryst., LI, p. 143.

Arsenopyrite

a: b: c = 0.6762:1:1.1917 (Flink 4)

δ	3∞	310	Deloro, Ontario, Can.		2
α	$0\frac{1}{2\,4}$	0.1.24	Serbia		1
β	$0\frac{1}{6}$	016	"		1
ϵ	$0\frac{5}{4}$	054	Deloro, Ontario, Can.		2
s	$0\frac{1\,7}{2}$	0.17.2	"	" "	2
	$\frac{1}{2}$	112	Franklin, N. J.		5
	2	221	Brosso, Italy		3
	$\frac{1}{2}2$	142	Franklin, N. J.		5
	$\frac{1}{2}\,\frac{3}{2}$	132	" "		5
	$\frac{5}{2}\,\frac{3}{2}$	532	" "		5

1.—A. Schmidt, 1888, Zeitschr. f. Kryst., XIV, p. 573.
2.—F. Scheerer, 1893, Zeitschr. f. Kryst., XXI, p. 354.
3.—L. Colomba, 1906, Rend. Accad. Linc., XV, p. 642.
4.—G. Flink, 1908, Arkiv f. Kemi. Min., (11) III, p. 1.
5.—C. Palache, 1910, Amer. Journ. Sci., XXIX, p. 177.

Arzrunite

Orthorhombic Axial ratio = ?

c	0	001	Tarapaca, Chile	1
b	0∞	010	" "	1

m	∞	110	Tarapaca, Chile	1
	02	021	" "	1
	1	111	" "	1

1.—A. Arzruni and K. Thaddéeff, 1899, Zeitschr. f. Kryst., XXXIII, p. 230.

Atacamite

γ	∞5	150	Paposo, Atacama, Chile	2
τ	$\left\{\begin{matrix}\infty\frac{9}{8}\\ \infty\frac{10}{9}\end{matrix}\right.$	$\left\{\begin{matrix}890\\ 9.10.0\end{matrix}\right.$?	Seirra Gorda, Chile	1
β	2∞	210	Paposo, Atacama, Chile	2
	$0\frac{1}{18}$	0.1.18	Boleo, Lower California, Mex.	3
	$0\frac{1}{9}$	019	" " " "	3
	$0\frac{1}{7}$	017	" " " "	3
	$0\frac{1}{6}$	016	" " " "	3
	$0\frac{1}{5}$	015	" " " "	3
	$0\frac{3}{5}$	035	" " " "	3
	$0\frac{5}{3}$	053	" " " "	3
	03	031	" " " "	3
	06	061	" " " "	3
	$\frac{1}{9}0$	109	" " " "	3
	$\frac{1}{8}0$	108	" " " "	3
	$\frac{1}{7}0$	107	" " " "	3
	$\frac{1}{6}0$	106	" " " "	3
	$\frac{2}{7}0$	207	" " " "	3
	$\frac{2}{5}0$	205	" " " "	3
	$\frac{5}{7}0$	507	" " " "	3
	$\frac{3}{4}0$	304	" " " "	3
	$\frac{7}{9}0$	709	" " " "	3
	$\frac{3}{2}0$	302	" " " "	3
Φ	13	131	Sierra Gorda, Chile	1
	$1\frac{3}{2}$	232	Boleo, Lower California, Mex.	3
	$1\frac{1}{8}$	818	" " " "	3
σ	$\frac{3}{2}$	332	Sierra Gorda, Chile	1
s	$\frac{4}{3}$	443	" " "	1
	$\frac{1}{2}$	112	Boleo, Lower California, Mex.	3
	$\frac{1}{4}$	114	" " " "	3
	$\frac{1}{5}$	115	" " " "	3
	$\frac{1}{7}$	117	" " " "	3
h	$\frac{1}{2}\frac{3}{2}$	132	Sierra Gorda, Chile	1

$\frac{1}{2}2$	142	Boleo, Lower California, Mex.		3
$\frac{1}{5}\frac{4}{5}$	145	" " " "		3
$\frac{2}{3}\frac{1}{3}$	213	" " " "		3
$\frac{1}{2}\frac{1}{4}$	214	" " " "		3

Uncertain Forms

$\frac{7}{8}0$	708	Boleo, Lower California, Mex.		3
$\frac{4}{5}0$	405	" " " "		3
$\frac{7}{12}0$	7.0.12	" " " "		3
$1\frac{2}{7}$	727	" " " "		3
$\frac{3}{8}1$	388	" " " "		3
$\frac{2}{9}\frac{7}{9}$	279	" " " "		3
$\frac{4}{7}\frac{11}{7}$	4.11.7	" " " "		3

1.—G. F. Herbert-Smith, 1898, Min. Mag., XII, p. 15.
2.—A. J. Moses, 1901, Amer. Journ. Sci., XII, p. 100.
3.—H. Ungemach, 1911, Bull. Soc. fr. Min., XXXIV, p. 148.

Augelite

$a:b:c = 1.6419:1:1.2708$ $\beta = 67° 33\frac{1}{2}'$

c	0	001	Bolivia	1
b	0∞	010	"	1
a	$\infty 0$	100	"	1
m	∞	110	"	1
g	9∞	910	"	2
x	-10	$\bar{1}01$	"	1
	01	011	"	1
n	$\frac{1}{2}$	112	"	1
o	$-\frac{1}{2}$	$\bar{1}12$	"	1

1.—G. T. Prior and L. J. Spencer, 1895, Min. Mag., XI, p. 16.
2.—L. J. Spencer, 1898, Min. Mag., XII, p. 1.

Axinite

	$\bar{1}\bar{7}\infty$	17.$\bar{1}$.0	Dauphiné, France	1
C	14∞	14.1.0	California	5
	8∞	810	Dauphiné, France	1
D	$\frac{7}{2}\infty$	7$\bar{2}$0	California	5
E	$\frac{9}{4}\infty$	9$\bar{4}$0	"	5
A	2∞	210	"	5
	$\frac{5}{3}\infty$	530	Dauphiné, France	1
p	$\frac{4}{3}$	4$\bar{3}$0	Quenast, Belgium	3

	$\frac{1}{1}\frac{1}{3}\infty$	17.13.0	Dauphiné, France	1
	$\frac{1}{9}^{1}\infty$	11.9.0	" "	1
	$\frac{1}{1}\frac{3}{1}\infty$	13.11.0	" "	1
	$-\frac{9}{8}\infty$	$9\bar{8}0$	" "	1
	$-\frac{1}{1}\frac{3}{2}\infty$	$13.\bar{1}\bar{2}.0$	" "	1
F	$-\infty\,\frac{1}{9}^{0}$	$9.\bar{1}0.0$	California	5
G	$-\infty\,\frac{8}{7}$	$7\bar{8}0$	"	3
γ	$\infty 2$	120	Nordmark, Sweden	2
	$-\infty 2$	$\bar{1}20$	" "	8
B_0	$-\infty\,\frac{7}{3}$	$3\bar{7}0$	Nickel Plate Mt., British Columbia	7
σ_0	$-\infty 3$	$1\bar{3}0$	" " " "	7
N	$-\infty\,\frac{9}{2}$	$2\bar{9}0$	California	5
A_0	$-\infty 6$	$1\bar{6}0$	Nickel Plate Mt., British Columbia	7
Ω	$-\infty 8$	$\bar{1}80$	" " " "	7
P	$-\infty 13$	$1.\bar{1}3.0$	California	5
ϑ	$-\infty 34$	$1.\bar{3}\bar{4}.0$	Quenast, Belgium	3
	$\infty 41$	1.41.0	Dauphiné, France	1
	$-0\frac{5}{8}$	$0\bar{5}8$	Biella, Italy	4
φ_0	$-0\frac{3}{4}$	$0\bar{3}4$	Nickel Plate Mt., British Columbia	7
Δ	02	021	" " " "	7
U	06	061	Nordmark, Sweden	2
R	08	081	" "	2
π	-09	$0\bar{9}1$	Quenast, Belgium	3
Σ	$\frac{1}{4}0$	104	Nickel Plate Mt., British Columbia	7
Π	$\frac{2}{5}0$	205	" " " "	7
Ψ_0	20	201	" " " "	7
	$\frac{\bar{1}}{5\,6}\frac{1}{5\,6}$	$\bar{1}.1.56$	Dauphiné, France	1
	$\frac{\bar{1}}{1\,6}\frac{1}{1\,6}$	$\bar{1}.1.16$	" "	1
	$\frac{1}{2}\frac{\bar{1}}{2}$	$1\bar{1}2$	Pic d'Arbizon, France	6
	$\frac{\bar{1}}{4}\frac{1}{4}$	$\bar{1}\bar{1}4$	" "	6
	$\frac{\bar{2}}{9}\frac{2}{9}$	$\bar{2}29$	Dauphiné, France	1
Z	$\bar{4}4$	$\bar{4}41$	Nordmark, Sweden	2
δ	$\bar{1}3$	$\bar{1}31$	Pic d'Arbizon, France	6
x_0	$\frac{\bar{3}}{2}\bar{1}$	$\bar{3}\bar{2}2$	Nickel Plate Mt., British Columbia	7
	$\frac{\bar{1}}{2}\frac{7}{6}$	$\bar{3}76$	Dauphiné, France	1
	$\frac{\bar{5}}{2}\frac{7}{2}$	$\bar{5}72$	" "	1
Q	$\frac{\bar{3}}{7}\frac{2}{7}$	$\bar{3}27$	Nordmark, Sweden	2
λ	$\frac{\bar{2}}{5}\frac{8}{5}$	$\bar{2}85$	" "	2
σ	$\frac{\bar{3}}{2}\frac{5}{2}$	$\bar{3}52$	Pic d'Arbizon, France	6
λ_0	$\frac{\bar{3}}{2}\frac{1}{2}$	$\bar{3}12$	Nickel Plate Mt., British Columbia	7

p_0	$\frac{7}{5}\,\frac{3}{5}$	735	Nickel Plate Mt., British Columbia	7
Θ	$\frac{2}{3}\,\frac{4}{3}$	243	Nordmark, Sweden	8
s	$\frac{1}{4}\,\frac{7}{4}$	$\bar{1}74$	" "	8
Σ	$\frac{1}{3}\,\frac{5}{3}$	$\bar{1}53$	" "	8

1.—A. Offret and F. Gonnard, 1893, Bull. Soc. fr. Min., XVI, p. 76.
2.—H. Sjögren, 1893, Bull. Geol. Inst. Upsala, p. 1.
3.—A. Franck, 1893, Bull. Ac. Belg., (3) XXV, p. 17.
4.—F. Zambonini, 1905, Zeitschr. f. Kryst., XL, p. 262.
5.—W. T. Schaller, 1911, Zeitschr. f. Kryst., XLVIII, p. 156.
6.—H. Ungemach, 1912, Bull. Soc. fr. Min., XXXV, p. 526.
7.—E. Poitevin, 1919, Amer. Miner., IV, p. 32.
8.—G. Flink, 1917, Arkiv Kemi. Min., Geol., VI, No. 21.

Azurite

	$\infty\frac{5}{3}$	350	Stadtberger, Siegen, Ger.	10
	$0\frac{1}{2}\,0$	0.1.20	Durango, Mex.	8
Λ	$0\frac{1}{1}\,0$	0.1.10	Pretoria, Transvaal, S. Africa	3
	$0\frac{1}{7}$	017	Durango, Mex.	8
	$-\frac{1}{8}\,0$	$\bar{1}9.0.8$	Tsumeb, S. W. Africa	9
$\mathfrak{M}$	$-\frac{1}{6}\,0$	$\bar{1}3.0.6$	Broken Hill, N. S. Wales	5
$\mathfrak{p}$	$-\frac{1}{8}\,0$	$\bar{1}5.0.8$	" " " "	5
	$-\frac{5}{3}\,0$	$\bar{5}03$	Tsumeb, S. W. Africa	9
$\mathfrak{r}$	$-\frac{4}{3}\,0$	$\bar{4}03$	Broken Hill, N. S. Wales	5
w	$+\frac{6}{5}\,0$	605	Laurium, Greece	2
	$-\frac{1}{1}\,\frac{1}{3}\,0$	$\bar{1}1.0.13$	Tsumeb, S. W. Africa	9
T	$-\frac{4}{5}\,0$	$\bar{4}05$	Laurium, Greece	2
$\mathfrak{b}$	$-\frac{2}{3}\,0$	$\bar{2}03$	Mineral Point, Wis.	4
$\mathfrak{c}$	$-\frac{3}{7}\,0$	$\bar{3}07$	" " "	4
I	$+\frac{2}{5}\,0$	205	Laurium, Greece	2
	$-\frac{4}{1}\,\frac{1}{1}\,0$	$\bar{4}.0.11$	Tsumeb, S. W. Africa	9
$\mathfrak{S}$	$-\frac{3}{1}\,\frac{1}{0}\,0$	$\bar{3}.0.10$	Moonta, S. Australia	5
$\mathfrak{L}$	$-\frac{3}{1}\,\frac{1}{1}\,0$	$\bar{3}.0.11$	Broken Hill, N. S. Wales	11
	$-\frac{3}{1}\,\frac{1}{4}\,0$	$\bar{3}.0.14$	Tsumeb, S. W. Africa	9
	$-\frac{4}{9}\,0$	$\bar{4}09$	" "	9
	$-\frac{2}{1}\,\frac{1}{1}\,0$	$\bar{2}.0.11$	" "	9
	$+\frac{1}{7}\,0$	107	" "	9
N	$\frac{\bar{1}}{7}\,\frac{4}{7}$	$\bar{4}47$	Longfellow Mine, Arizona	1
	$\bar{7}7$	$\bar{7}71$	Tsumeb, S. W. Africa	9
Ω	$1\frac{1}{2}$	212	Bisbee, Arizona	11
Γ	$\frac{2}{3}2$	263	Pretoria, Transvaal, S. Africa	3

	$\bar{2}6$	$\bar{2}61$	Chessy, France	6
W	$\frac{1}{1}\frac{1}{5}$	1.3.15	Pretoria, Transvaal, S. Africa	3
R	$\bar{2}4$	$\bar{2}41$	Moonta, S. Australia	5
♭	$\frac{9}{8}\frac{3}{2}$	9.12.8	Mineral Point, Wis.	4
G	$\bar{3}2$	$\bar{3}21$	Morenci, Arizona	1
K	$\frac{1}{5}\frac{2}{}2$	$\bar{1}\bar{2}.10.5$	" "	1
♭	$\frac{5}{8}\frac{1}{4}$	$\bar{5}28$	Agua Galiente, Peru	7
	$\frac{1}{2}5$	$\bar{1}.10.2$	Chessy, France	6

1.—O. C. Farrington, 1891, Amer. Journ. Sci., XLI, p. 300.
2.—K. Zimányi, 1892, Zeitschr. f. Kryst., XXI, p. 86.
3.—G. A. F. Molengraaf, 1893, Zeitschr. f. Kryst., XXII, p. 156.
4.—W. H. Hobbs, 1895, Bull. Univ. Wis., I, p. 145.
5.—C. Steiner, 1906, Ann. Mus. Nat. Hung., IV, p. 293.
6.—G. Cesáro, 1905, Bull. Ac. Belg., p. 130.
7.—E. Hunek, 1910, Zeitschr. f. Kryst., XLIX, p. 11.
8.—H. Ungemach, 1910, Bull. Soc. fr. Min., XXXIII, p. 25.
9.—Z. v. Toborffy, 1913, Zeitschr. f. Kryst., LII, p. 225.
10.—J. F. Oebike, 1915, Inaug.-Diss. Münster i. Westf. p. 56.
11.—G. Aminoff, 1919, Arkiv Kemi. Min., Geol., VII, No. 17.

Babingtonite

k	$-\infty$	$1\bar{1}0$	Sommerville, Mass.	1
u	$0\frac{5}{4}$	054	" "	1
v	$0\frac{3}{5}$	035	" "	1
w	$0\frac{2}{5}$	025	" "	1
n	-10	$\bar{1}01$	" "	1
y	$\frac{2}{5}0$	205	" "	1
x	$\frac{3}{5}0$	305	" "	1
p	1	111	" "	1
t	$\frac{1}{2}$	112	" "	1
i	$-\frac{1}{2}$	$\bar{1}12$	" "	1

1.—C. Palache and F. R. Fraprie, 1902, Proc. Amer. Acad., XXXVIII, p. 382.

Bäckstromite

a: b: c = 0.7393:1:0.6918

b	0∞	010	Långban, Sweden	1
l	2∞	210	" "	1
m	∞	110	" "	1
d	01	011	" "	1
q	02	021	" "	1

y	12	121	Långban, Sweden	1
z	13	131	" "	1
u	15	151	" "	1
x	21	211	" "	1

1.—G. Aminoff, 1919, Geol. Fören. Förh., XLI, p. 473.

Baddeleyite

$a:b:c = 0.9768:1:1.0475 \quad \beta = 81° 20'$

c	0	001	São Paulo, Brazil	2
a	$\infty 0$	100	Rakwana, Ceylon	1
b	0∞	010	" "	1
g	2∞	210	Balangoda, Ceylon	3
m	∞	110	Rakwana, Ceylon	1
l	$\infty \frac{3}{2}$	230	São Paulo, Brazil	2
k	$\infty 2$	120	" "	2
d	01	011	Rakwana, Ceylon	1
d_1	02	021	São Paulo, Brazil	2
s	$\frac{2}{3}0$	203	" "	2
r	—10	$\bar{1}01$	" "	2
t	10	101	" "	2
x	20	201	" "	2
α	—20	$\bar{2}01$	Balangoda, Ceylon	3
n	—1	$\bar{1}11$	São Paulo, Brazil	2
p	2	221	Balangoda, Ceylon	3

1.—L. Fletcher, 1893, Min. Mag., X, p. 145.
2.—E. Hussak, 1892, Neues Jahrb. f. Min., II, p. 141.
3.—G. S. Blake and G. F. Herbert-Smith, 1907, Min. Mag., XIV, p. 378.

Barite

ϑ	9∞	910	Russia	22
Σ_3	5∞	510	McCormick, S. C.	35
	$\frac{10}{7} \infty$	10.7.0	Laconia, Sardinia	34
e_1	$\frac{4}{3} \infty$	430	Belgium	18
E	$\frac{6}{5} \infty$	650	Hüttenberg, Carinthia, Austria	9
	$\infty \frac{5}{4}$	450	Hastigen, Sweden	8
M	$\infty \frac{7}{5}$	570	Russia	22
π_1	$\infty \frac{5}{3}$	350	Traversella, Italy	26
χ_1	$\infty \frac{5}{2}$	250	Lunkány, Hungary	11
F	$\infty \frac{8}{3}$	380	McCormick, S. C.	35

U	$\infty\,\frac{1}{4}\,1$	4.11.0	Hüttenberg, Carinthia, Austria	9
E_1	$\infty 7$	170	Traversella, Italy	26
E_2	$\infty 10$	1.10.0	" "	26
B	$\infty 22$	1.22.0	Hüttenberg, Carinthia, Austria	9
R	$\infty 30$	1.30.0	" " "	9
B_1	$\infty 44$	1.44.0	" " "	9
A_1	$0\frac{1}{2}\,0$	0.1.20	" " "	9
A	$0\frac{1}{1}\,6$	0.1.16	" " "	9
$\mathfrak{a}$	$0\frac{1}{1}\,2$	0.1.12	Templeton, Canada	10
a_6	$0\frac{1}{6}$	016	Belgium	2
	$0\frac{2}{7}$	027	Sympheropol, Crymea	28
	$0\frac{2}{5}$	025	Harstigen, Sweden	8
	$0\frac{4}{7}$	047	Gömör, Hungary	30
ϵ	$0\frac{3}{5}$	035	Harstigen, Sweden	8
j	$0\frac{3}{4}$	034	Russia	22
ϵ_2	$0\frac{4}{5}$	045	Mies, Bohemia	25
ϵ_3	$0\frac{6}{7}$	067	" "	25
j_3	$0\frac{5}{3}$	053	Five Islands, Nova Scotia	35
	$0\frac{8}{5}$	085	Aquadoro Valley, Italy	23
	$0\frac{8}{3}$	083	Colorado	29
o_7	07	071	Midlothian, Scotland	1
c_1	$\frac{1}{2}\frac{1}{5}0$	1.0.25	Montevecchio, Sardinia	12
w	$\frac{2}{1}\frac{1}{3}0$	2.0.13	Kongsberg, Norway	31
	$\frac{7}{2}\frac{1}{0}0$	7.0.20	Lubine, France	29
$\mathrm{d}\frac{3}{8}$	$\frac{3}{8}0$	308	Midlothian, Scotland	1
K	$\frac{5}{1}\frac{1}{3}0$	5.0.13	Kongsberg, Norway	31
V	$\frac{3}{7}0$	307	Harz Mts., Germany	4
	$\frac{4}{7}0$	407	Gömör, Hungary	30
S	$\frac{4}{5}0$	405	Harz Mts., Germany	4
F	$\frac{5}{6}0$	506	Bergheim, Alsace, France	13
μ_2	$\frac{4}{3}0$	403	Montevecchio, Sardinia	12
P_2	$\frac{2}{6}\frac{1}{3}$	2.2.63	Bergheim, Alsace, France	13
	$\frac{1}{2}\frac{1}{7}$	1.1.27	Freiberg, Saxony, Germany	5
Q_2	$\frac{1}{2}\frac{1}{6}$	1.1.26	Bergheim, Alsace and Harz Mts.	13+15
e_1	$\frac{1}{1}\frac{1}{7}$	1.1.17	Traversella, Italy	26
e_2	$\frac{1}{1}\frac{1}{4}$	1.1.14	" "	26
j_1	$\frac{1}{1}\frac{1}{0}$	1.1.10	Valsugana, Tyrol	7
p_1	$\frac{1}{7}$	117	Waldshut, Baden, Germany	6
f_1	$\frac{2}{5}$	225	Odenwald, Germany	17
B_2	$\frac{2}{7}$	227	Russia	22

B_3	$\frac{3}{7}$	337	Russia	22
	$\frac{8}{7}$	887	Colorado	29
ψ	$\frac{5}{4}$	554	Fehn, Norway	31
R_1	$\frac{10}{7}$	10.10.7	Russia	22
$\mathfrak{p}$	$\frac{7}{2}$	772	Dobsina, Hungary	16
s	5	551	Frostburg, Md.	27
ϑ	$1\frac{2}{7}$	727	Traversella, Italy	
Y_3	$\frac{1}{16}1$	1.16.16	Mies, Bohemia	25
Y_2	$\frac{1}{9}1$	199	" "	25
Y_1	$\frac{1}{8}1$	188	" "	25
Y	$\frac{1}{7}1$	177	Harz Mts., Germany	4
Ψ	$\frac{1}{6}1$	166	Mies, Bohemia	25
J	$\frac{3}{5}1$	355	Caucasus	14
P	$\frac{3}{4}1$	344	Midlothian, Scotland	1
Δ_2	$\frac{5}{2}1$	522	Kladno, Bohemia	33
Θ_1	$\frac{1}{20}\frac{2}{2}\frac{3}{0}$	1.23.20	Harstigen, Sweden	8
Γ_3	$\frac{1}{24}\frac{2}{3}$	1.16.24	Mies, Bohemia	25
Γ	$\frac{1}{32}\frac{1}{2}$	1.16.32	" "	25
Υ	$\frac{1}{11}\frac{1}{11}\frac{2}{1}$	1.12.11	" "	25
i	$\frac{1}{6}\frac{3}{2}$	196	Odenwald, Germany	17
Y_6	$\frac{1}{5}\frac{8}{5}$	185	Kladno, Bohemia	33
μ_3	$\frac{1}{9}\frac{7}{9}$	179	Mies, Bohemia	25
s_1	$\frac{1}{3}2$	163	Montevecchio, Sardinia	12
s_2	$\frac{1}{4}\frac{3}{2}$	164	Mies, Bohemia	25
Ψ_2	$\frac{1}{5}\frac{6}{5}$	165	Five Islands, Nova Scotia	35
Ψ_3	$\frac{1}{7}\frac{6}{7}$	167	" "	35
μ_2	$\frac{1}{8}\frac{3}{4}$	168	Mies, Bohemia	25
Γ_2	$\frac{1}{9}\frac{2}{3}$	169	" "	25
Θ_3	$\frac{2}{9}\frac{5}{3}$	2.15.9	Kladno, Bohemia	33
s_2	$\frac{1}{4}\frac{4}{3}$	3.16.12	Freiberg, Saxony, Germany	32
Y	$\frac{1}{2}\frac{5}{2}$	152	Island of San Pietro, Sardinia	21
μ_1	$\frac{1}{7}\frac{5}{7}$	157	Montevecchio, Sardinia	12
W_2	$\frac{1}{8}\frac{5}{8}$	158	Kladno, Bohemia	33
W_1	$\frac{1}{9}\frac{5}{9}$	159	Freiberg, Saxony, Germany	5
K	$\frac{2}{7}\frac{6}{7}$	267	Tetschen, Bohemia	19
δ	$\frac{1}{7}\frac{3}{7}$	137	Freiberg, Saxony, Germany	5
t_2	$\frac{2}{3}\frac{5}{3}$	253	Mies, Bohemia	25
φ_1	$\frac{2}{11}\frac{5}{11}$	2.5.11	Montevecchio, Sardinia	12
Δ_1	$\frac{7}{16}\frac{17}{16}$	7.17.16	Belgium	18
χ	$\frac{1}{3}\frac{2}{3}$	123	Montevecchio, Sardinia	12

μ_4	$\frac{1}{6}\frac{1}{3}$	126	Kladno, Bohemia	33
$\mathfrak{h}$	$\frac{1}{8}\frac{1}{4}$	128	Neurode, Germany	3
$\mathfrak{d}$	$\frac{1}{4\,0}\frac{1}{2\,0}$	1.2.40	Harz Mts., Germany	4
Ξ_2	$\frac{1}{4\,4}\frac{1}{2\,2}$	1.2.44	Freiberg, Saxony, Germany	5
	$\frac{3}{2}2$	342	Colorado	29
τ^1	$\frac{3}{4}\frac{1}{2}$	324	Midlothian, Scotland	1
τ^2	$\frac{3}{8}\frac{1}{4}$	328	Kladno, Bohemia	33
λ^1	$\frac{2}{3}\frac{1}{3}$	213	Midlothian, Scotland	1
λ_2	$\frac{1}{2}\frac{1}{4}$	214		24
λ_5	$\frac{2}{5}\frac{1}{5}$	215	McCormick, S. C.	35
σ^1	$\frac{1}{5}\frac{1}{1\,1}$	11.5.55	Midlothian, Scotland	1
ω	$\frac{4}{3}\frac{4}{9}$	12.4.9	Harz Mts., Germany	4
Y_1	$\frac{1\,1}{8}\frac{3}{8}$	11.3.8	Auvergn, France	20
$\mathfrak{r}$	$\frac{3}{2}\frac{1}{4}$	614	Freiberg, Saxony, Germany	32
	$\frac{1\,2}{1\,1}\frac{8}{3\,3}$	36.8.33?	Laconi, Sardinia	34
	$4\frac{1\,6}{7}$	28.16.7	Hüttenberg, Carinthia, Austria	9

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23.—E. Artini, 1903, Att. Soc. Milano, XLII, p. 102.
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Barysilite

Hexagonal $a:c=1:0.4683$

c	0	0001	Långban, Sweden	1
s	10	$10\bar{1}1$	" "	1
r	$\frac{9}{7}0$	$90\bar{9}7$	" "	1
	40	$40\bar{4}1$	Jacobsberg, Sweden	2
n	$\frac{1}{2}\frac{7}{4}$	$27\bar{9}4$	Långban, Sweden	1

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2.—G. Flink, 1917, Ark. Kemi. Min., Geol., VI, No. 21, p. 33.

Baumhauerite

$a:b:c=1.1368:1:0.9471 \quad \beta=82°\,43'$

c	0	001	Binnenthal, Switzerland	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
$\frac{1}{2}^1$s	$\frac{1}{2}^1\infty$	11.2.0	" "	1
$\frac{1}{3}^1$s	$\frac{1}{3}^1\infty$	11.3.0	" "	1
$\frac{1}{3}^0$s	$\frac{1}{3}^0\infty$	10.3.0	" "	1
3s	3∞	310	" "	1
$\frac{3}{8}$s	$\frac{8}{3}\infty$	830	" "	1
$\frac{5}{2}$s	$\frac{5}{2}\infty$	520	" "	1
$\frac{1}{8}^7$s	$\frac{1}{8}^7\infty$	17.8.0	" "	1
2s	2∞	210	" "	1
$\frac{9}{5}$s	$\frac{9}{5}\infty$	950	" "	1
$\frac{3}{2}$s	$\frac{3}{2}\infty$	320	" "	1
$\frac{9}{8}$s	$\frac{9}{8}\infty$	980	" "	1
r	∞	110	" "	1
$\frac{4}{3}$r	$\infty\frac{4}{3}$	340	" "	1
2r	$\infty 2$	120	" "	1
4r	$\infty 4$	140	" "	1
$\frac{1}{2}$l	$0\frac{1}{2}$	012	" "	1
k	01	011	" "	1
2k	02	021	" "	1

—30h	+30.0	30.0.1	Binnenthal, Switzerland		1
—25h	+25.0	25.0.1	"	"	3
—19h	+19.0	19.0.1	"	"	3
—$\frac{25}{2}$h	+$\frac{25}{2}$0	25.0.2	"	"	1
—$\frac{19}{2}$h	+$\frac{19}{2}$0	19.0.2	"	"	3
—9h	+90	901	"	"	3
—$\frac{17}{2}$h	+$\frac{17}{2}$0	17.0.2	"	"	3
—$\frac{15}{2}$h	+$\frac{15}{2}$0	15.0.2	"	"	3
—$\frac{13}{2}$h	+$\frac{13}{2}$0	13.0.2	"	"	1
—5h	+50	501	"	"	1
—$\frac{9}{2}$h	+$\frac{9}{2}$0	902	"	"	1
—4h	+40	401	"	"	1
—$\frac{7}{2}$h	+$\frac{7}{2}$0	702	"	"	1
—3h	+30	301	"	"	1
—$\frac{13}{5}$h	+$\frac{13}{5}$0	13.0.5	"	"	1
—$\frac{5}{2}$h	+$\frac{5}{2}$0	502	"	"	1
—$\frac{13}{6}$h	+$\frac{13}{6}$0	13.0.6	"	"	1
—2h	+20	201	"	"	1
—$\frac{13}{7}$h	+$\frac{13}{7}$0	13.0.7	"	"	1
—$\frac{3}{2}$h	+$\frac{3}{2}$0	302	"	"	1
—$\frac{7}{5}$h	+$\frac{7}{5}$0	705	"	"	1
—$\frac{4}{3}$h	+$\frac{4}{3}$0	403	"	"	1
—$\frac{7}{6}$h	+$\frac{7}{6}$0	706	"	"	2
—$\frac{13}{12}$h	+$\frac{13}{12}$0	13.0.12	"	"	1
—h	+10	101	"	"	1
—$\frac{5}{6}$g	+$\frac{5}{6}$0	506	"	"	1
—$\frac{4}{5}$g	+$\frac{4}{5}$0	405	"	"	1
—$\frac{3}{4}$g	+$\frac{3}{4}$0	304	"	"	1
—$\frac{5}{8}$g	+$\frac{5}{8}$0	508	"	"	1
—$\frac{1}{2}$g	+$\frac{1}{2}$0	102	"	"	1
—$\frac{2}{5}$g	+$\frac{2}{5}$0	205	"	"	1
—$\frac{1}{3}$g	+$\frac{1}{3}$0	103	"	"	1
—$\frac{1}{4}$g	+$\frac{1}{4}$0	104	"	"	1
—$\frac{1}{6}$g	+$\frac{1}{6}$0	106	"	"	1
—$\frac{1}{7}$g	+$\frac{1}{7}$0	107	"	"	1
—$\frac{1}{9}$g	+$\frac{1}{9}$0	109	"	"	1
+8h	—80	80$\bar{1}$	"	"	1
+$\frac{15}{2}$h	—$\frac{15}{2}$0	15.0.$\bar{2}$	"	"	3
+7h	—70	70$\bar{1}$	"	"	3
+6h	—60	60$\bar{1}$	"	"	3

$+\frac{1}{2}^{1}$h	$-\frac{1}{2}^{1}$0	11.0.$\bar{2}$	Binnenthal, Switzerland		1
+5h	−50	50$\bar{1}$	"	"	1
$+\frac{9}{2}$h	$-\frac{9}{2}$0	90$\bar{2}$	"	"	3
+4h	−40	40$\bar{1}$	"	"	1
$+\frac{7}{2}$h	$-\frac{7}{2}$0	70$\bar{2}$	"	"	3
+3h	−30	30$\bar{1}$	"	"	1
$+\frac{1}{4}^{3}$h	$-\frac{1}{4}^{3}$0	13.0.$\bar{4}$	"	"	3
$+\frac{1}{4}^{1}$h	$-\frac{1}{4}^{1}$0	11.0.$\bar{4}$	"	"	3
$+\frac{5}{2}$h	$-\frac{5}{2}$0	50$\bar{2}$	"	"	1
$+\frac{9}{4}$h	$-\frac{9}{4}$0	90$\bar{4}$	"	"	3
$+\frac{1}{5}^{1}$h	$-\frac{1}{5}^{1}$0	11.0.$\bar{5}$	"	"	1
+2h	−20	20$\bar{1}$	"	"	1
$+\frac{1}{7}^{3}$h	$-\frac{1}{7}^{3}$0	13.0.$\bar{7}$	"	"	1
$+\frac{1}{6}^{1}$h	$-\frac{1}{6}^{1}$0	11.0.$\bar{6}$	"	"	3
$+\frac{7}{4}$h	$-\frac{7}{4}$0	70$\bar{4}$	"	"	1
$+\frac{5}{3}$h	$-\frac{5}{3}$0	50$\bar{3}$	"	"	2
$+\frac{8}{5}$h	$-\frac{8}{5}$0	80$\bar{5}$	"	"	2
$+\frac{3}{2}$h	$-\frac{3}{2}$0	30$\bar{2}$	"	"	1
$+\frac{4}{3}$h	$-\frac{4}{3}$0	40$\bar{3}$	"	"	3
$+\frac{5}{4}$h	$-\frac{5}{4}$0	50$\bar{4}$	"	"	3
+h	−10	10$\bar{1}$	"	"	1
$+\frac{5}{6}$g	$-\frac{5}{6}$0	50$\bar{6}$	"	"	3
$+\frac{3}{4}$g	$-\frac{3}{4}$0	30$\bar{4}$	"	"	1
$+\frac{2}{3}$g	$-\frac{2}{3}$0	20$\bar{3}$	"	"	1
$+\frac{5}{9}$g	$-\frac{5}{9}$0	50$\bar{9}$	"	"	3
$+\frac{1}{2}$g	$-\frac{1}{2}$0	10$\bar{2}$	"	"	1
$+\frac{2}{5}$g	$-\frac{2}{5}$0	20$\bar{5}$	"	"	3
$+\frac{3}{8}$g	$-\frac{3}{8}$0	30$\bar{8}$	"	"	2
$+\frac{1}{3}$g	$-\frac{1}{3}$0	10$\bar{3}$	"	"	2
$+\frac{1}{4}$g	$-\frac{1}{4}$0	10$\bar{4}$	"	"	1
$+\frac{1}{6}$g	$-\frac{1}{6}$0	10$\bar{6}$	"	"	3
$+\frac{2}{1\,3}$g	$-\frac{2}{1\,3}$0	2.0.$\bar{13}$	"	"	1
$+\frac{1}{7}$g	$-\frac{1}{7}$0	10$\bar{7}$	"	"	3
$+\frac{1}{9}$g	$-\frac{1}{9}$0	10$\bar{9}$	"	"	1
$+\frac{1}{1\,2}$g	$-\frac{1}{1\,2}$0	1.0.$\bar{12}$	"	"	3
−2q	+12	121	"	"	1
−p	+1	111	"	"	1
+2q	−12	12$\bar{1}$	"	"	1
+p	−1	11$\bar{1}$	"	"	1
+u	−2	21$\bar{1}$	"	"	1

—4x	$+\frac{3}{2}2$	342	Binnenthal, Switzerland	1
—2x	$+\frac{3}{2}1$	322	" "	1
+2x	$-\frac{3}{2}1$	$32\bar{2}$	" "	1
—4n	$+\frac{1}{2}2$	142	" "	1
—2n	$+\frac{1}{2}1$	122	" "	1
+4n	$-\frac{1}{2}2$	$14\bar{2}$	" "	1
+2n	$-\frac{1}{2}1$	$12\bar{2}$	" "	1
—2y	$+\frac{5}{2}1$	522	" "	1
+2y	$-\frac{5}{2}1$	$52\bar{2}$	" "	1
+z	—31	$31\bar{1}$	" "	1
—w	+41	411	" "	1
—3W	$+\frac{10}{3}1$	10.3.3	" "	1
—3V	$+\frac{16}{3}1$	16.3.3	" "	1
+4m	$-\frac{1}{4}1$	$14\bar{4}$	" "	1
—10T	$+\frac{4}{5}2$	4.10.5	" "	1

1.—R. H. Solly, 1903, Min. Mag., XIII, p. 151.
2.—H. Baumhauer, Cited by Solly in (1)
3.—R. H. Solly, 1903, Min. Mag., XIII, p. 336.

Bavenite

a: b: c = 1.1751:1:0.7845 $\beta = 89° 17'$

a	0	100	Baveno, Italy	1
g	2∞	210	" "	1
m	∞	110	" "	1
	+10	101	" "	1
	$+\frac{1}{3}0$	103	" "	1

1.—E. Artini, 1901, Rend. Accad. Linc., X, p. 139.

Beckelite

Isometric

a	0	100	Mariupol, Russia	1
d	∞	110	" "	1
o	1	111	" "	1

1.—J. Morozewicz, 1905, Min. Mitth., XXIV, p. 120.

Benitoite

Hexagonal *a: c* = 1:0.7319

c	0	0001	San Benito Co., Calif.	1
a	∞	$11\bar{2}0$	" "	1
m	+∞0	$10\bar{1}0$	" "	1

u	$-\infty 0$	$01\bar{1}0$	San Benito Co., Cal.	3
p	$+10$	$10\bar{1}1$	" "	1
π	-10	$01\bar{1}1$	" "	1
r	$+\frac{1}{2}0$	$10\bar{1}2$	" "	5
e	$-\frac{1}{2}0$	$01\bar{1}2$	" "	2
x	2	$22\bar{4}1$	" "	3
D	$\frac{2}{3}$	$22\bar{4}3$	" "	4

1.—G. D. Louderback, 1907, Univ. Calif. Pub., V, p. 149.
2.—A. F. Rogers, 1908, Science, XXVIII, p. 616.
3.—C. Palache, 1909, Amer. Journ. Sci., XXVII, p. 398.
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Bertrandite

f	$\infty 3$	130	Oxford Co., Maine	1
e	03	031	" "	1
k	0.12	0.12.1	" "	1
l	$\frac{2}{3}0$	203	Albany, Maine	2

1.—S. L. Penfield, 1897, Amer. Journ. Sci., IV, p. 316.
2.—O. C. Farrington and E. W. Tillotson,1908, Field Col. Mus., Geol. Ser., III, p. 136.

Beryl

s	13∞	$13.1.\bar{1}\bar{4}.0$	Russia	2
E	4∞	$41\bar{5}0$	Minas Geraes, Brazil	5
Ψ	$\frac{1}{12}0$	$1.0.\bar{1}.12$	Alexander Co., N. C.	1
	$\frac{1}{3}0$	$10\bar{1}3$	Bahia, Brazil	6
v	$\frac{4}{5}0$	$40\bar{4}5$	Russia	2
Y	$\frac{11}{12}0$	$11.0.\bar{1}\bar{1}.12$	Minas Geraes, Brazil	5
ϵ	$\frac{6}{5}0$	$60\bar{6}5$	Pisek, Bohemia	3
	$\frac{9}{4}0$	$90\bar{9}4$	Bahia, Brazil	6
	$\frac{5}{2}0$	$50\bar{5}2$	" "	6
μ	$\frac{1}{6}$	$11\bar{2}6$	Russia	2
ξ	$\frac{1}{4}$	$11\bar{2}4$	Pisek, Bohemia	3
o	$\frac{3}{8}$	$33\bar{6}8$	Minas Geraes, Brazil	5
	$\frac{3}{2}$	$33\bar{6}2$	Bahia, Brazil	6
	$\frac{9}{2}$	$9.9.\bar{1}\bar{8}.2$	" "	6
φ	$\frac{4}{3}\frac{7}{6}$	$7.8.\bar{1}\bar{5}.6$	Alexander Co., N. C.	1
x	$\frac{8}{7}1$	$8.7.\bar{1}\bar{5}.7$	" "	1
ψ	$\frac{9}{8}\frac{7}{8}$	$9.7.\bar{1}\bar{6}.8$	" "	1
	$\frac{1}{3}\frac{1}{6}$	$21\bar{3}6$	Bahia, Brazil	6

N	$\frac{5}{2}1$	$52\bar{7}2$	Minas Geraes, Brazil	5
V	$\frac{8}{3}\,\frac{2}{3}$	$8.2.\bar{10}.3$	" " "	5
	$\frac{11}{3}\,\frac{2}{3}$	$11.2.\bar{13}.3$	Elba, Italy	4
W	61	6171	Minas Geraes, Brazil	5
λ	15.1	$15.1.\bar{16}.1$	Pisek, Bohemia	3
	19.1	$19.1.\bar{20}.1$	Russia	2

1.—W. E. Hidden and H. S. Washington, 1887, Amer. Journ. Sci., XXXIII, p. 501.
2.—P. Jeremejew, 1892, Verh. Min. Ges., XXIX, p. 230 and 1895, XXXIII, p. 26.
3.—C. Vrba, 1894, Zeitschr. f. Kryst., XXIV, p. 104.
4.—G. d'Archardi, 1904, Soc. Tosc. d. sc. nat. Pisa.
5.—H. Kohlmann, 1908, Neues Jahrb. f. Min., Beil. B., XXV, p. 142.
6.—P. Siedel, 1915, Neues Jahrb. f. Min., Beil. B., XXXVIII, p. 760.

Binnite

(See Tetrahedrite)

Bismite

Hexagonal *a: c* = 1:0.5775

c	0	0001	Gold Field Dist., Nevada	1
o	$\frac{1}{6}0$	$10\bar{1}6$	" " " "	1
q	$\frac{1}{5}0$	$10\bar{1}5$	" " " "	1
u	$\frac{1}{4}0$	$10\bar{1}4$	" " " "	1
k	$\frac{1}{3}0$	$10\bar{1}3$	" " " "	1
	$\frac{2}{5}0$	$20\bar{2}5$?	" " " "	1
	$\frac{1}{2}0$	$10\bar{1}2$?	" " " "	1

1.—W. T. Schaller and F. L. Ransome, 1910, Amer. Journ. Sci., XXIX, p. 173.

Bixbyite

Isometric

a	$\infty 0$	100	Simpson, Utah	1
n	$\frac{1}{2}$	112	" "	1

1.—S. L. Penfield and H. W. Foote, 1897, Amer. Journ. Sci., IV, p. 105.

Blomstrandine-Priorite

a: b: c = 0.4746:1:0.6673

c	0	001	Hitterö and Arendal, Norway	1
a	$\infty 0$	100	" " " "	1
b	0∞	010	" " " "	1
m	∞	110	" " " "	1
r	$\infty 2$	120	" " " "	1

n	∞3	130	Hitterö and Arendel, Norway				1
t	∞4	140	"	"	"	"	1
x	02	021	"	"	"	"	1
d	10	101	"	"	"	"	1
p	1	111	"	"	"	"	1
π	12	121	"	"	"	"	1

1.—W. C. Brögger, 1906, Min. d. Sudnorw. Gran. peg., p. 98.

Boléite

Tetragonal *a: c* = 1:3.996

0	001	Boleo, Lower California, Mex.				1
8∞	810	"	"	"	"	2
$\frac{17}{4}$∞	17.4.0	"	"	"	"	2
4∞	410	"	"	"	"	2
$\frac{5}{2}$∞	520	"	"	"	"	2
$\frac{5}{3}$∞	530	"	"	"	"	2
$\frac{5}{4}$∞	540	"	"	"	"	2
$\frac{8}{7}$∞	870	"	"	"	"	2
10	101	"	"	"	"	1

1.—G. Friedel, 1906, Bull. Soc. fr. Min., XXIX, p. 14.
2.—A. Hadding, 1919, Geol. Fören. Förh., XLI, p. 175.

Boothite

a: b: c = 1.1622:1:1.500 β = 74° 24′

c	0	001	Alameda and Calaveras Cos., Calif.				1
a	∞0	100	"	"	"	"	" 1
m	∞	110	"	"	"	"	" 1
t	—10	$\bar{1}01$	"	"	"	"	" 1
z	—30	$\bar{3}01$	"	"	"	"	" 1
π	—$\frac{1}{2}$	$\bar{1}12$	"	"	"	"	" 1
e	—1	$\bar{1}11$	"	"	"	"	" 1
σ	—12	$\bar{1}21$	"	"	"	"	" 1

1.—W. T. Schaller, 1903, Univ. Calif. Pub., III, p. 207.

Botryogen

a: b: c = 0.6554:1:0.5994 β = 62° 51′

a	∞0	100	Knoxville, Calif.		1
t	∞$\frac{5}{4}$	450	"	"	1
v	0$\frac{2}{3}$	023	"	"	1

o	$0\frac{3}{4}$	034	Knoxville, Calif.	1
d	$-\frac{4}{3}0$	$\bar{4}03$	" "	1
p	$-\frac{2}{3}$	$\bar{2}23$	" "	1
s	$-\frac{2}{3}\frac{4}{3}$	$\bar{2}43$	" "	1

1.—A. S. Eakle, 1903, Amer. Journ. Sci., XVI, p. 379.

Boulangerite

a: b: c = 0.5527:1:0.7478

a	$\infty 0$	100	Sala, Sweden	1
b	0∞	010	" "	1
r	2∞	210	" "	1
q	$\frac{3}{2}\infty$	320	" "	1
m	∞	110	" "	1
n	$\infty 2$	120	" "	1
μ	$\infty 4$	140	" "	1
l	$\infty 6$	160	" "	1
h	$\infty 8$	180	" "	1
i	$\infty 10$	1.10.0	" "	1
h	$\infty 14$	1.14.0	" "	1
w	$0\frac{1}{2}$	012	" "	1

1.—Hj. Sjögren, 1897, Geol. Fören. Förh., XIX, p. 153.

Bournonite

	$\frac{19}{5}\infty$	19.5.0	Puy-de-Dôme, France	2
	$\frac{18}{5}\infty$	18.5.0	" "	2
C	$\frac{5}{3}\infty$	530	Pulacayo, Bolivia	4
	$\frac{9}{5}\infty$	950	Isère, France	3
	$\infty\frac{8}{7}$	780	" "	3
	$\infty\frac{8}{3}$	380	" "	3
	$0\frac{3}{2}$	032	" "	3
$\hat{\delta}$	02	021	Nagybánya, Hungary	1
c	$\frac{5}{3}0$	503	" "	1
$\mathfrak{g}$	60	601	Pulacayo, Bolivia	4
	$\frac{4}{9}$	449	" "	4
β_1	$\frac{5}{12}\frac{7}{12}$	5.7.12	Puy-de-Dôme, France	2
s	$\frac{5}{8}\frac{3}{4}$	568	Isère, "	3
V_1	$\frac{5}{5}\frac{0}{9}\frac{6}{5}\frac{6}{9}$	50.66.59	Puy-de-Dôme, "	2
t	$\frac{1}{4}\frac{1}{4}\frac{3}{4}$	11.3.4	Isère, "	3
a	$\frac{9}{8}\frac{1}{8}$	918	Puy-de-Dôme, "	2

1.—A. Schmidt, 1892, Zeitschr. f. Kryst., XX, p. 151.
2.—F. Gonnard, 1897, Bull. Soc. fr. Min., XX, p. 312.
3.—P. Termier, 1897, Bull. Soc. fr. Min., XX, p. 101.
4.—B. Mauritz, 1905, Ann. Mus. Nat. Hung., III, p. 46.

Brandtite

$a:b:c = 0.8720:1:0.4475 \quad \beta = 99° 37'$

$\infty 0$	100	Harstigen, Sweden	1
0∞	010	" "	1
2∞	210	" "	1
$\frac{3}{2} \infty$	320	" "	1
∞	110	" "	1
$\infty \frac{3}{2}$	230	" "	1
$\infty 2$	120	" "	1
1	111	" "	1
—1	$\bar{1}11$	" "	1
$1\frac{1}{2}$	212	" "	1
12	121	" "	1

1.—G. Aminoff, 1919, Geol. Fören. Förh., XLI, p. 161.

Braunite

Dana's Orientation

a	$\infty 0$	100	Långban, Sweden	1
m	∞	110	" "	1
o	$\frac{3}{4}0$	304	" "	1
q	$\frac{5}{6}0$	506	Minas Geraes, Brazil	3
n	10	101	Långban, Sweden	1
d	20	201	Brazil	2
l	40	401	Långban, Sweden	1
r	60	601	Minas Geraes, Brazil	3
b	80	801	Brazil	5
τ	$\frac{1}{3}$	113	"	2
γ	$\frac{1}{2}$	112	"	5
w	13	131	Minas Geraes, Brazil	3
g	$1\frac{1}{2}$	212	Långban, Sweden	1
y	$\frac{4}{3}\frac{2}{3}$	423	" "	1
ρ	$\frac{8}{5}\frac{6}{5}$	865	India	4
n	64	641	Brazil	5
σ	$\frac{6}{5}\frac{4}{5}$	645	Långban, Sweden	1
u	$2\frac{4}{3}$	643	Minas Geraes, Brazil	3

	$\frac{5}{2}\,\frac{3}{2}$	532	Brazil	5
t	$\frac{5}{4}\,\frac{1}{2}$	524	Långban, Sweden	1
v	$\frac{3}{2}\,\frac{1}{2}$	312	Minas Geraes, Brazil	3
j	62	621	Brazil	5
δ	82	821	"	5
ϵ	$\frac{8}{3}\,\frac{2}{3}$	823	"	2
	12.2	12.2.1	"	5
f	$\frac{7}{4}\,\frac{1}{4}$	714	"	2
μ	$\frac{7}{3}\,\frac{1}{3}$	713	Minas Geraes, Brazil	3
λ	$\frac{16}{3}2$	16.6.3	Brazil	5
	$\frac{22}{3}2$	22.6.3	"	5
	24.2	24.2.1	"	5

1.—G. Flink, 1891, Bihang. k. k. Sven. Vet. Ak., XVI, (2).
2.—R. Koechlin, 1908, Min. u. petro. Mitth., XXVII, p. 266.
3.—B. Ježek, 1908, Bull. Ac. Sci. Böhm., XIII.
4.—L. L. Fermor, 1909, Mem. Geol. Surv., India, XXXVII, p. 53.
*5.—R. Koechlin, 1913, Ann. Mus. Wein, XXVII, p. 159.

Breithopite

Hexagonal $a:c=1:0.8627$

	70	$70\bar{7}1$	Andreasberg, Germany	1

1.—H. Busz, 1895, Neues Jahrb. f. Min., I, p. 119.

Britholite

Hexagonal $a:c=1:0.7247$

m	$\infty 0$	$10\bar{1}0$	Julianehaab, Greenland	1
a	∞	$11\bar{2}0$	" "	1
p	10	$10\bar{1}1$	" "	1

1.—O. B. Böggild, 1911, Zeitschr. f. Kryst., L, p. 430.

Brochanthite

	$\frac{5}{2}\,\frac{3}{2}$	532	Utah	1

1.—F. Zambonini, 1901, Zeitschr. f. Kryst., XXXIV, p. 238.

Brookite

L	$\infty\frac{3}{2}$	230	Princeton, N. J.	7
φ	$\infty 2$	120	Magnet Cove, Ark.	1
D	$0\frac{2}{5}$	025	Princeton, N. J.	7
T	04	041	" "	7

g	$\frac{3}{5}0$	305	Brazil	2
ι	10	101	Brindletown, N. C.	4
X	$1\frac{1}{3}$	313?	Princeton, N. J.	7
v	$\frac{1}{4}\,\frac{1}{2}$	124	Brazil	2
σ	$\frac{3}{4}\,\frac{1}{2}$	324	Sondalo, Veltlin, Italy	3
ξ	$\frac{1}{6}\,\frac{1}{4}$	146	Brazil	2
E	$\frac{5}{4}1$	544	Sommerville, Mass.	6
β	$\frac{1}{2}\,\frac{2}{5}$	5.4.10	Brindletown, N. C.	4
F	$\frac{5}{4}\,\frac{3}{4}$	534	Sommerville, Mass.	6
G	$1\frac{1}{9}^{0}$	9.10.9	" "	6
ϑ	$\frac{5}{17}\,\frac{1}{1}\frac{3}{7}$	5.13.17	Tremadoc, Wales	5

1.—E. S. Dana, 1886, Amer. Journ. Sci., XXXII, p. 314.
2.—E. Hussak, 1892, Min. Mitth., XII, p. 460.
3.—L. Brugnatelli, 1899, Rend. Inst. Lomb., XXXII, p. 1405.
4.—H. H. Robinson, 1901, Amer. Journ. Sci., XII, p. 182.
5.—H. Busz, 1901, Neues Jahrb. f. Min., II, p. 135.
6.—C. Palache, 1906, Festschr. 70 Geburst. Rosenbush, p. 311.
7.—A. C. Hawkins, 1913, Amer. Journ. Sci., XXXV, p. 446.

Calamine

a: b: c = 0.78897:1:0.48698

K	$0\frac{1}{5}$	015	Santa Eulalia, Chihuahua, Mex.	6
U	$0\frac{1}{4}$	014	" " " "	6
O	05	051	" " " "	6
θ	$\frac{5}{1}\frac{}{2}0$	5.0.12?	" " " "	6
Γ	$\frac{3}{7}0$	307?	" " " "	6
Δ	$\frac{4}{9}0$	409?	" " " "	6
j	$\frac{4}{7}0$	407	Organ Mts., N. Mex.	4
S	$\frac{5}{4}0$	504	Ghergur, Algeria	3
	$\frac{5}{3}0$	503	Gorno, Valserine, Italy	1
T	$\frac{5}{2}0$	502	Ghergur, Algeria	3
s	$\frac{3}{4}$	334	Vielle Montagne, Belgium	5
N	41	411	Santa Eulalia, Chihuahua, Mex.	6
	—21	$21\bar{1}$	Moresnet, Belgium	2
L	$\frac{4}{3}1$	433	Santa Eulalia, Chihuahua, Mex.	6
V	$\frac{7}{2}\,\frac{3}{2}$	732	" " " "	6
Q	$3\frac{3}{2}$	632	" " " "	6
H	$\frac{9}{7}\,\frac{6}{7}$	967	" " " "	6
W	$\frac{5}{4}\,\frac{3}{4}$	534	" " " "	6
J	$\frac{7}{5}\,\frac{6}{5}$	765	" " " "	6

Ξ	$\frac{5}{9}\ \frac{4}{9}$	549?	Santa Eulalia, Chihuahua, Mex.				6
Λ	$\frac{4}{9}\ \frac{5}{9}$	459?	"	"	"	"	6

1.—E. Artini, 1896, Riv. Min. Ital., XVI, p. 19.
2.—H. Buttgenbach, 1897, Ann. Soc. Géol. Belg., XXIV.
3.—E. Billows, 1908, Riv. Min. Ital., XXXIV, p. 47.
4.—W. E. Ford and F. Ward, 1909, Amer. Journ. Sci., XXVIII, p. 185.
5.—V. Goldschmidt and R. Schroeder, 1911, Zeitschr. f. Kryst., XLIX, p. 135.
6.—M. Seebach and E. P. Paul, 1912, Zeitschr. f. Kryst., LI, p. 149.

Calaverite

$a:b:c = 1.6313:1:1.1449 \quad \beta = 89° 47'$

c	0	001	Cripple Creek, Colo.			1
a	$\infty 0$	100	"	"	"	1
b	0∞	010	"	"	"	1
m	∞	110	"	"	"	1
I	$\frac{2}{11}0$	2.0.11	"	"	"	1
H	$\frac{5}{11}0$	5.0.11	"	"	"	1
D	$\frac{3}{4}0$	304	"	"	"	1
G	$\frac{13}{10}0$	13.0.10	"	"	"	1
F	$\frac{11}{5}0$	11.0.5	"	"	"	1
E	$\frac{5}{2}0$	502	"	"	"	1
C_1	40	401	"	"	"	1
C	50	501	"	"	"	1
B_3	$\frac{75}{11}0$	75.0.11	"	"	"	1
B	80	801	"	"	"	1
B_1	$\frac{17}{2}0$	17.0.2	"	"	"	1
B_2	90	901	"	"	"	1
L	$-\frac{1}{4}0$	$\bar{1}04$	"	"	"	1
M_1	$-\frac{9}{10}0$	$\bar{9}.0.10$	"	"	"	1
M	-10	$\bar{1}01$	"	"	"	1
M_2	$-\frac{11}{10}0$	$\bar{11}.0.10$	"	"	"	1
N_1	$-\frac{11}{6}0$	$\bar{11}.0.6$	"	"	"	1
N	-20	$\bar{2}01$	"	"	"	1
N_2	$-\frac{24}{11}0$	$\bar{24}.0.11$	"	"	"	1
P	$-\frac{11}{2}0$	$\bar{11}.0.2$	"	"	"	1
P_1	$-\frac{25}{4}0$	$\bar{25}.0.4$	"	"	"	1
R	-90	$\bar{9}01$	"	"	"	1
R_1	-110	$\bar{11}.0.1$	"	"	"	1
R_2	-150	$\bar{15}.0.1$	"	"	"	1
e	$+4$	441	"	"	"	1

p	$+1$	111	Cripple Creek, Colo.	1
f	$+\frac{1}{2}$	112	" " "	1
w	-1	$\bar{1}11$	" " "	1
μ	$+\frac{17}{2}20$	17.40.2	" " "	1
t	$+\frac{13}{4}5$	13.20.4	" " "	1
g	$+\frac{11}{5}\frac{29}{5}$	11.29.5	" " "	1
h	$+\frac{21}{11}\frac{37}{11}$	21.37.11	" " "	1
ω	$+\frac{5}{3}\frac{5}{4}$	20.15.12	" " "	1
o	$+\frac{13}{10}\frac{11}{5}$	13.22.10	" " "	1
n	$+\frac{11}{10}\frac{7}{5}$	11.14.10	" " "	1
i	$+\frac{10}{11}\frac{7}{11}$	10.7.11	" " "	1
π	$+\frac{22}{27}\frac{2}{3}$	22.18.27	" " "	1
g_1	$+\frac{5}{11}\frac{15}{22}$	10.15.22	" " "	1
g	$+\frac{2}{5}\frac{7}{10}$	4.7.10	" " "	1
y	$+\frac{1}{3}\frac{3}{2}$	296	" " "	1
v	$+\frac{2}{5}\frac{11}{10}$	2.11.10	" " "	1
k	$-\frac{10}{21}\frac{32}{21}$	$\bar{1}0.32.21$	" " "	1
r	$-\frac{2}{3}\frac{44}{15}$	$\bar{1}0.44.15$	" " "	1
u	$-\frac{11}{10}\frac{9}{5}$	$\bar{1}\bar{1}.18.10$	" " "	1
j	$-\frac{7}{6}\frac{5}{6}$	$\bar{7}56$	" " "	1
x	$-\frac{11}{6}\frac{10}{3}$	$\bar{1}\bar{1}.20.6$	" " "	1
s	$-\frac{11}{6}\frac{31}{3}$	$\bar{1}\bar{1}.62.6$	" " "	1
s_1	-2.11	$\bar{2}.11.1?$	" " "	1
σ	-2.10	$\bar{2}.10.1?$	" " "	1
τ	$-\frac{31}{11}\frac{38}{11}$	$\bar{3}\bar{1}.38.11$	" " "	1
z	-15.22	$\bar{1}5.22.1$	" " "	1
ρ	$-22.\frac{21}{2}$	$\bar{4}\bar{4}.21.2$	" " "	1

1.—S. L. Penfield and W. E. Ford, 1901, Amer. Journ. Sci., XII, p. 225.

Calcite

$\mathfrak{b}$	19∞	$19.1.\bar{2}\bar{0}.0$	Arendal, Norway	43
ψ	10∞	$10.1.\bar{1}\bar{1}.0$	Neumark, Germany	13
σ	7∞	$71\bar{8}0$	Bergen Hill, N. J.	32
μ	$\frac{5}{3}\infty$	$53\bar{8}0$	Smith's Basin, N. Y.	35
j	$\frac{7}{6}\infty$	$7.6.\bar{1}\bar{3}.0$	Andreasberg, Germany	31
v	2	$11\bar{2}1$	Lake Superior, Mich.	20
ω	$\frac{32}{9}$	$16.16.\bar{3}\bar{2}.9$	" " "	20
ρ	$\frac{18}{5}$	$9.9.\bar{1}\bar{8}.5$	Långban, Sweden	41
h^2	$\frac{21}{4}$	21.21.42.8	" "	42

s	$\frac{2}{3}0$	10.10.$\bar{2}\bar{0}$.3	Nordmark, Sweden	41
χ	10	5.5.$\bar{1}\bar{0}$.1	Frizington, England	22
φ	16	8.8.$\bar{1}\bar{6}$.1	Smith's Basin, N. Y.	35
c	24.0	24.0.$\bar{2}\bar{4}$.1	Mineral Point, Wis.	12
	11.0	11.0.$\bar{1}\bar{1}$.1	Andreasberg, Germany	4
	80	80$\bar{8}$1	Rhisnes, Belgium	6
	$\frac{1}{2}\frac{3}{0}$	13.0.$\bar{1}\bar{3}$.1	Rauris, Salzberg, Germany	8
R.	20	20$\bar{2}$1	Lake Superior, Mich.	20
M.	$\frac{3}{2}0$	30$\bar{3}$2	Långban, Sweden	41
$\mathfrak{d}$	$\frac{1}{3}0$	10$\bar{1}$3	" "	41
$\mathfrak{a}$	$-\frac{1}{2}\frac{1}{0}0$	0.11.$\bar{1}\bar{1}$.20	Mineral Point, Wis.	12
$\mathfrak{b}$	$-\frac{1}{2}\frac{8}{5}0$	0.18.$\bar{1}\bar{8}$.25	" " "	12
o	$-\frac{1}{1}\frac{4}{7}0$	0.14.$\bar{1}\bar{4}$.17	Hillsboro, N. Mex.	31
	$-\frac{1}{2}\frac{9}{0}0$	0.19.$\bar{1}\bar{9}$.20	Archennes, Belgium	6
	$-\frac{1}{1}\frac{7}{6}0$	0.17.$\bar{1}\bar{7}$.16	Rhisnes, Belgium	6
H:	$-\frac{1}{1}\frac{8}{3}0$	0.18.$\bar{1}\bar{8}$.13	Edgewater, N. J.	22
Y	$-\frac{1}{1}\frac{9}{3}0$	0.19.$\bar{1}\bar{9}$.13	Lyon Mountain, N. Y.	29
	$-\frac{1}{1}\frac{4}{1}0$	0.14.$\bar{1}\bar{4}$.11	Norberg, Sweden	10
N.	$-\frac{1}{7}0$	0.10.$\bar{1}\bar{0}$.7	Karta, Sweden	41
	$-\frac{8}{5}0$	08$\bar{8}$5	Narsarsuk, Greenland	18
	$-\frac{5}{3}0$	05$\bar{5}$3	Andreasberg, Germany	4
	$-\frac{7}{4}0$	07$\bar{7}$4	" "	4
	$-\frac{1}{6}0$	0.11.$\bar{1}\bar{1}$.6	" "	4
	$-\frac{1}{8}\frac{7}{}0$	0.17.$\bar{1}\bar{7}$.8	Limburg, "	36
g_1	$-\frac{1}{5}\frac{3}{}0$	0.13.$\bar{1}\bar{3}$.5	Stromberg, "	40
$\mathfrak{g}$	$-\frac{1}{5}\frac{6}{}0$	0.16.$\bar{1}\bar{6}$.5	Budapest, Hungary	14
J.	$-\frac{1}{4}\frac{3}{}0$	0.13.$\bar{1}\bar{3}$.4	Great Notch, N. J.	22
Q.	-70	07$\bar{7}$1	Rondout, N. Y.	35
	$-\frac{2}{4}\frac{9}{}0$	0.29.$\bar{2}\bar{9}$.4	Dillenberg, Germany	34
	-10.0	0.10.$\bar{1}\bar{0}$.1	" "	34
	-12.0	0.12.$\bar{1}\bar{2}$.1	Budapest, Hungary	14
	-13.0	0.13.$\bar{1}\bar{3}$.1	Rauris, Salzberg, Germany	8
	-18.0	0.18.$\bar{1}\bar{8}$.1	Dillenberg, Germany	34
	-20.0	0.20.$\bar{2}\bar{0}$.1	Joplin, Mo.	21
	-28.0	0.28.$\bar{2}\bar{8}$.1	Andreasberg, Germany	4
	-36.0	0.36.$\bar{3}\bar{6}$.1	Norberg, Sweden	10
	$-\frac{6}{1}\frac{}{3}\frac{1}{1}\frac{}{3}$	1.6.$\bar{7}$.13	San Francisco, Calif.	31
	$-\frac{4}{9}\frac{}{}\frac{1}{9}$	14$\bar{5}$9	Körösmezö, Hungary	15
r:	$-\frac{1}{2}\frac{2}{9}\frac{}{}\frac{5}{2}\frac{}{9}$	5.12.$\bar{1}\bar{9}$.29	Utö, Sweden	41
	$-\frac{7}{1}\frac{}{8}\frac{2}{9}$	4.7.$\bar{1}\bar{1}$.18	Körösmezö, Hungary	15

	$-\frac{5}{13}\frac{3}{13}$	3.5.$\bar{8}$.13	Lake Superior, Mich.	20
ſ:	$\frac{8}{22}\frac{7}{22}$	8.7.$\bar{15}$.22	Norberg, Sweden	41
	$\frac{5}{13}\frac{4}{13}$	5.4.$\bar{9}$.13	Körösmezö, Hungary	15
	$\frac{3}{7}\frac{2}{7}$	32$\bar{5}$7	Bamle, Norway	1
	$\frac{11}{23}\frac{6}{23}$	11.6.$\bar{17}$.23	Couzon, Rhône, France	16
ɦ	$\frac{11}{21}\frac{5}{21}$	11.5.$\bar{16}$.21	Terlingua, Texas	31
	$\frac{7}{13}\frac{3}{13}$	7.3.$\bar{10}$.13	Couzon, Rhône, France	16
e	$\frac{9}{13}\frac{2}{13}$	9.2.$\bar{11}$.13	Budapest, Hungary	14
s:	$\frac{8}{7}\frac{1}{7}$	81$\bar{9}$7	Sala, Sweden	41
	$\frac{13}{10}\frac{3}{10}$	13.3.$\bar{16}$.10	Andreasberg, Germany	4
	$\frac{21}{16}\frac{5}{16}$	21.5.$\bar{26}$.16	Neumark, Germany	13
	$\frac{11}{8}\frac{3}{8}$	11.3.$\bar{14}$.8	Engis, Belgium	3
λ:	$\frac{17}{12}\frac{5}{12}$	17.5.$\bar{22}$.12	Great Notch, N. J.	22
v:	$\frac{22}{15}\frac{7}{15}$	22.7.$\bar{29}$.15	Bölet, Sweden	41
ρ:	$\frac{25}{16}\frac{9}{16}$	25.9.$\bar{34}$.16	Hesselkulla, Sweden	41
a:	$\frac{8}{5}\frac{3}{5}$	8.3.$\bar{11}$.5	Långban, Sweden	41
	$\frac{7}{4}\frac{3}{4}$	7.3.$\bar{10}$.4	Montecatini, Italy	17
	$\frac{11}{6}\frac{5}{6}$	11.5.$\bar{16}$.6	Neumark, Germany	13
	$\frac{15}{8}\frac{7}{8}$	15.7.$\bar{22}$.8	" "	13
	$\frac{13}{4}\frac{9}{4}$	13.9.$\bar{22}$.4	Limburg, "	36
	$\frac{41}{20}\frac{21}{20}$	41.21.$\bar{62}$.20	Schafbachthal, Switzerland	7
b:	$\frac{29}{14}\frac{15}{14}$	29.15.$\bar{44}$.14	Bölet, Sweden	41
	$\frac{25}{12}\frac{13}{12}$	25.13.$\bar{38}$.12	Schafbachthal, Switzerland	7
	$\frac{19}{8}\frac{11}{8}$	19.11.$\bar{30}$.8	Montecatini, Italy	5
	$\frac{12}{5}\frac{7}{5}$	12.7.$\bar{19}$.5	Iceland?	44
	$\frac{29}{12}\frac{17}{12}$	29.17.$\bar{46}$.12	Neumark, Germany	13
c:	$\frac{13}{5}\frac{8}{5}$	13.8.$\bar{21}$.5	Limburg, Germany	36
	$\frac{17}{6}\frac{11}{6}$	17.11.$\bar{28}$.6	Lake Superior, Mich.	20
	$\frac{17}{4}\frac{13}{4}$	17.13.$\bar{30}$.4	Plainfield, N. J.	32
d:	$\frac{11}{2}\frac{9}{2}$	11.9.$\bar{20}$.2	Limburg, Germany	36
	$\frac{15}{2}\frac{13}{2}$	15.13.$\bar{28}$.2	Framont, Alsace, France	11
	87	8.7.$\bar{15}$.1	Salgótarján, Nogard, Hungary	30
	10.9	10.9.$\bar{19}$.1	Montecatini, Italy	17
	$\frac{21}{2}\frac{19}{2}$	21.19.$\bar{40}$.2	Arendal, Norway	7
	$\frac{5}{6}\frac{1}{3}$	52$\bar{7}$6	Körösmezö, Hungary	15
	$-\frac{5}{4}\frac{1}{4}$	51$\bar{6}$4	Salgótarján, Nogard, Hungary	30
a	$-\frac{5}{3}\frac{1}{6}$	1.10.$\bar{11}$.6	Budapest, Hungary	14
	$-\frac{7}{3}\frac{1}{3}$	17$\bar{8}$3	Couzon, Rhône, France	16
t:	$-\frac{14}{3}\frac{8}{3}$	8.14.$\bar{22}$.3	Lyon Mountain, N. Y.	35
s:	—64	4.6.$\bar{10}$.1	Rondout, N. Y.	35

	$-\frac{11}{6}\frac{1}{3}$	2.11.$\overline{13}$.6	Rhisnes, Belgium	6
	$-\frac{20}{11}\frac{4}{11}$	4.20.$\overline{24}$.11	Budapest, Hungary	14
	$-\frac{12}{7}\frac{4}{7}$	4.12.$\overline{16}$.7	Rhisnes, Belgium	6
π:	$\frac{10}{3}\frac{1}{3}$	10.1.$\overline{11}$.3	Lake Superior, Mich.	20
o	$\frac{8}{3}\frac{2}{3}$	8.2.$\overline{10}$.3	Hillsboro, N. Mex.	31
Γ:	$\frac{17}{4}\frac{1}{4}$	17.1.$\overline{18}$.4	Lake Superior, Mich.	20
Δ	$\frac{13}{3}\frac{1}{3}$	13.1.$\overline{14}$.3	" " "	20
Σ	$\frac{22}{5}\frac{2}{5}$	22.2.$\overline{24}$.5	" " "	20
Θ:	$\frac{40}{9}\frac{4}{9}$	40.4.$\overline{44}$.9	" " "	20
Φ	$\frac{9}{2}\frac{1}{2}$	9.1.$\overline{10}$.2	" " "	20
Λ:	$\frac{32}{7}\frac{4}{7}$	32.4.$\overline{36}$.7	" " "	20
	$\frac{14}{3}\frac{2}{3}$	14.2.$\overline{16}$.3	Rhisnes, Belgium	6
	$\frac{16}{3}\frac{4}{3}$	16.4.$\overline{20}$.3	Tharandt, Saxony, Germany	19
	$\frac{11}{2}\frac{3}{2}$	11.3.$\overline{14}$.3	Catskill, N. Y.	35
	$\frac{15}{2}\frac{7}{2}$	15.7.22.2	Rhisnes, Belgium	6
	$\frac{17}{2}\frac{9}{2}$	17.9.26.2	" "	6
g:	$\frac{7}{2}1$	72$\overline{9}$2	Nordmark, Sweden	41
U:	$\frac{10}{3}\frac{4}{3}$	10.4.$\overline{14}$.3	Lake Superior, Mich.	20
	$\frac{19}{6}\frac{5}{3}$	19.10.$\overline{29}$.6	Rhisnes, Belgium	6
u	$\frac{14}{5}\frac{12}{5}$	14.12.$\overline{26}$.5	Lyon Mountain, N. Y.	29
	$-\frac{17}{12}\frac{5}{12}$	5.17.$\overline{22}$.12	Rauris, Salzberg, Germany	8
F	$-\frac{11}{6}\frac{5}{6}$	5.11.$\overline{16}$.6	Lake Superior, Mich.	20
	$-\frac{7}{3}\frac{4}{3}$	4.7.$\overline{11}$.3	Couzon, Rhône, France	16
	$-\frac{5}{2}\frac{3}{2}$	3582	Narsarsuk, Greenland	18
X	$\frac{16}{3}\frac{7}{3}$	16.7.$\overline{23}$.3	Terlingua, Texas	27
e	$-\frac{11}{2}\frac{1}{2}$	1.11.$\overline{12}$.2	Sommerville, N. Y.	35
v	-72	27$\overline{9}$1	Budapest, Hungary	14
j:	$2\frac{3}{2}$	42$\overline{7}$2	Långban, Sweden	41
w	$\frac{7}{6}\frac{2}{3}$	7.4.$\overline{11}$.6	Lake Superior, Mich.	20
	$-\frac{36}{13}\frac{19}{13}$	19.36.$\overline{55}$.13	Couzon, Rhône, France	16
f:	$\frac{7}{2}\frac{7}{4}$	14.7.$\overline{21}$.4	Långban, Sweden	41
$\mathfrak{N}$	$-\frac{28}{9}\frac{7}{9}$	7.28.$\overline{35}$.9	Skorrvång, Sweden	41
f	$-\frac{20}{13}\frac{6}{13}$	6.20.$\overline{26}$.13	Lake Superior, Mich.	20
	$-\frac{11}{7}\frac{3}{7}$	3.11.$\overline{14}$.7	Andreasberg, Germany	4
t	$-\frac{13}{8}\frac{3}{8}$	3.13.$\overline{16}$.8	Plainfield, N. J.	32
D	$-2\frac{3}{4}$	3.8.$\overline{11}$.4	Lake Superior, Mich.	20
A	$-2\frac{6}{7}$	6.14.$\overline{20}$.7	" " "	20
	$\frac{16}{5}2$	16.10.$\overline{26}$.5	Norberg, Sweden	10
$\mathfrak{H}$	$\frac{9}{2}2$	9.4.$\overline{13}$.2	Howes Cave, N. Y.	35
	52	52$\overline{7}$1	Budapest, Hungary	14

I	$-\frac{1}{8}\frac{7}{8}$	7.17.$\overline{24}$.8	Lake Superior, Mich.	20
J	$-\frac{2}{9}\frac{0}{9}\frac{8}{9}$	8.20.$\overline{28}$.9	Guanajuato, Mexico	9
	$-\frac{2}{1}\frac{3}{0}\frac{9}{1}\frac{9}{0}$	9.23.$\overline{23}$.10	Couzon, Rhône, France	16
B	$-\frac{4}{1}\frac{0}{1}\frac{1}{1}\frac{2}{1}$	12.40.$\overline{52}$.11	Lake Superior, Mich.	20
o	$-\frac{3}{2}\frac{5}{8}$	5.12.$\overline{17}$.8	Utö, Sweden	41
	$3\frac{4}{3}$	15.4.$\overline{19}$.3	Freiberg, Germany	7
	$5\frac{7}{5}$	25.7.$\overline{32}$.5	Dortmund, Germany	23
	$5\frac{3}{2}$	10.3.$\overline{13}$.2	Freiberg, Germany	7
f:	$\frac{7}{2}\frac{3}{2}$	7.3.$\overline{10}$.2	Långban, Sweden	41
z	$\frac{1}{1}\frac{6}{5}\frac{4}{1}\frac{5}{5}$	16.4.$\overline{20}$.15	Lake Superior, Mich.	20
N	$\frac{1}{1}\frac{2}{1}\frac{4}{1}\frac{5}{1}$	12.4.$\overline{16}$.11	" " "	20
H	$\frac{6}{5}\frac{3}{5}$	63$\overline{9}$5	West Paterson, N. J.	28
	$\frac{1}{9}\frac{0}{9}\frac{7}{9}$	10.7.$\overline{17}$.9	Körösmezö, Hungary	15
J.	$-\frac{1}{1}\frac{9}{2}\frac{1}{2}\frac{7}{4}$	17.38.$\overline{55}$.24	Lake Superior, Mich.	20
	$-\frac{2}{7}\frac{4}{7}$	3.24.$\overline{27}$.7	Bamle, Norway	1
L	$\frac{2}{3}\frac{2}{7}\frac{8}{3}\frac{8}{7}$	22.8.$\overline{30}$.37	Andreasberg, Germany	4
	$\frac{7}{2}3$	7.6.$\overline{13}$.2	Norberg, Sweden	10
a	$\frac{3}{2}\frac{7}{1}\frac{1}{2}\frac{9}{1}$	37.19.$\overline{56}$.21	Lake Superior, Mich.	20
b	$\frac{4}{3}\frac{1}{1}\frac{1}{5}$	20.11.$\overline{31}$.15	" " "	20
M	$\frac{8}{5}\frac{4}{5}$	8.4.$\overline{12}$.5	" " "	20
	$\frac{5}{2}\frac{5}{4}$	10.5.$\overline{15}$.4	Blaton, Belgium	2
P	$\frac{1}{3}\frac{3}{3}\frac{7}{3}$	13.7.$\overline{20}$.3	Lake Superior, Mich.	20
l	$\frac{3}{8}\frac{9}{8}\frac{1}{8}\frac{5}{8}$	39.15.$\overline{54}$.8	Rossie, N. Y.	35
	$\frac{1}{3}\frac{7}{3}\frac{8}{3}$	17.8.$\overline{25}$.3	Rhisnes, Belgium	6
	$\frac{6}{1}\frac{3}{1}\frac{2}{1}\frac{8}{1}$	63.28.$\overline{91}$.11	Budapest, Hungary	14
U'''	61	61$\overline{7}$1	Belgium	25
D	$\frac{7}{6}\frac{5}{1}\frac{5}{8}$	21.5.$\overline{26}$.18	Kelley's Island, Ohio	37
e^3	$2\frac{3}{2}$	43$\overline{7}$2	Långban, Sweden	42
e^1	$\frac{7}{6}\frac{7}{1}\frac{7}{2}$	14.7.$\overline{21}$.12	" "	42
h^1	$\frac{1}{5}\frac{6}{5}\frac{1}{5}\frac{4}{5}$	16.14.$\overline{30}$.5	" "	42
g^1	$\frac{2}{5}\frac{1}{5}\frac{8}{5}$	21.8.$\overline{29}$.5	" "	42
t:	$\frac{2}{9}\frac{8}{9}\frac{1}{9}\frac{6}{9}$	28.16.$\overline{44}$.9	Sweden	41
f:	$\frac{8}{3}\frac{4}{3}$	8.4.$\overline{12}$.3	Långban, Sweden	41
h:	$\frac{7}{6}\frac{7}{1}\frac{7}{2}$	14.7.$\overline{21}$.12	Sweden	41
O	$3\frac{8}{3}$	9.8.$\overline{17}$.3	Långban, Sweden	41
D	$\frac{2}{5}\frac{1}{5}\frac{8}{5}$	21.8.$\overline{29}$.5	" "	41
o	$\frac{1}{5}\frac{6}{5}\frac{1}{5}\frac{4}{5}$	16.14.$\overline{30}$.5	" "	41
ρ^1	$\frac{3}{3}\frac{2}{5}\frac{2}{3}\frac{4}{5}$	32.24.$\overline{56}$.35	Stromberg, Germany	40
	$\frac{1}{5}\frac{8}{5}\frac{1}{5}\frac{2}{5}$	18.12.$\overline{30}$.5	Dillenberg, "	34
	$\frac{2}{3}\frac{5}{3}\frac{2}{3}\frac{0}{3}$	25.20.$\overline{45}$.3	" "	34

D^1	$4\frac{8}{3}$	12.8.$\overline{20}$.3		38
v:	$\frac{11}{3}\frac{4}{3}$	11.4.$\overline{15}$.3	Joplin, Mo.	33
μ:	$\frac{20}{11}1$	20.11.$\overline{31}$.11	Belleville, Ohio	33
E	$-\frac{56}{69}\frac{32}{69}$	32.56.$\overline{88}$.69	Lake Superior, Mich.	20
	$-\frac{3}{2}\frac{2}{3}$	4.9.$\overline{13}$.6	Neumark, Sweden	13
	$-\frac{20}{21}\frac{2}{21}$	2.20.$\overline{22}$.21	Rhisnes, Belgium	6
	$-\frac{20}{17}\frac{4}{17}$	4.20.$\overline{24}$.17	Utö, Sweden	7
♁	$-\frac{36}{31}\frac{4}{31}$	4.36.$\overline{40}$.31	Lake Superior, Mich.	20
C	$-\frac{13}{10}\frac{1}{10}$	1.13.$\overline{14}$.10	West Paterson, N. J.	28
K	$-\frac{11}{8}\frac{1}{8}$	1.11.$\overline{12}$.8	Lake Superior, Mich.	20
☾	$-\frac{10}{3}1$	3.10.$\overline{13}$.3	Hillsboro, New Mex.	31
	$-\frac{61}{26}\frac{3}{26}$	3.61.$\overline{64}$.26	Rhisnes, Belgium	6
	$-\frac{59}{17}\frac{16}{17}$	16.59.$\overline{75}$.17	Couzon, Rhône, France	16
	$-8\frac{3}{2}$	3.16.$\overline{19}$.2	Budapest, Hungary	14
	$-\frac{68}{35}\frac{12}{35}$	12.68.$\overline{80}$.35	Neumark, Germany	13
	-13.1	1.13.$\overline{14}$.1	Freiberg, "	7
☿	$-\frac{15}{2}\frac{3}{2}$	3.15.$\overline{18}$.2	Union Springs and Rondout, N. Y.	35
♅	$-\frac{13}{4}\frac{3}{2}$	6.13.$\overline{19}$.4	Kelley's Island, Ohio	37
h^5	$-\frac{13}{8}\frac{3}{4}$	6.13.$\overline{19}$.8	Utö, Sweden	42
h^6	$-\frac{3}{2}\frac{5}{8}$	5.12.$\overline{17}$.8	" "	42
	-10.6	6.10.$\overline{16}$.1?	Greenland	26
	$-\frac{35}{2}\frac{21}{2}$	21.35.$\overline{56}$.2	Limburg, Germany	36
B_{11}	$-\frac{50}{29}\frac{13}{29}$	13.50.$\overline{63}$.29	Stromberg, "	40
B_1	$-\frac{12}{5}\frac{3}{5}$	3.12.$\overline{15}$.5	" "	40
x_1	$-\frac{125}{48}\frac{35}{48}$	35.125.$\overline{160}$.48	" "	40
	$-\frac{36}{11}\frac{8}{11}$	8.36.$\overline{44}$.11	Dillenberg, "	34
	-25.15	15.25.$\overline{40}$.1	" "	34
♇	$-\frac{9}{2}\frac{9}{20}$	9.45.$\overline{54}$.20	Utö, Sweden	41
♇	$-\frac{38}{17}\frac{22}{17}$	22.38.$\overline{60}$.17	" "	41
$\mathfrak{M}$	$-\frac{9}{2}\frac{27}{20}$	27.45.$\overline{72}$.20	" "	41
☋	$-5\frac{5}{4}$	5.20.$\overline{25}$.4	Nordmark and Visby, Sweden	41
	-20.12	12.20.$\overline{32}$.1	Stromberg, Germany	40

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Caledonite

a: b: c = 0.9190:1:2.8228

$0\frac{1}{5}$	015	Red Gill, Scotland	1
$0\frac{1}{3}$	013	" " "	1
$0\frac{2}{3}$	023	" " "	1
02	021	Lead Hills, "	1
03	031	" " "	1
05	051	" " "	1

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Calomel

l	$\infty 2$	120	Avala, Belgrad, Servia	3
ξ	$\infty \frac{2}{2}$	290	" " "	1
g	$\infty 6$	160	" " "	2
j	$\frac{4}{7}0$	407	Donna Anna Co., N. Mex.	5
j	$0\frac{1}{1\,2}$	0.1.12	Terlingua, Texas	4
Y	$0\frac{1}{8}$	018	" "	4
δ	$0\frac{1}{6}$	016	" "	3
q	$0\frac{1}{5}$	015	Avala, Belgrad, Servia	2
t	$0\frac{1}{2}$	012	" " "	2
Φ	$0\frac{3}{5}$	035	Terlingua, Texas	4
β	$0\frac{5}{4}$	054	Avala, Belgrad, Servia	1
d	03	031	Terlingua, Texas	3
k	04	041	Avala, Belgrad, Servia	1
H	$\frac{1}{2\,4}$	1.1.24	Terlingua, Texas	4
ϵ	$\frac{1}{7}$	117	" "	4
h	$\frac{1}{4}$	114	Avala, Belgrad, Servia	1
T	$\frac{3}{4}$	334	Terlingua, Texas	4
K	$\frac{5}{3}$	553	" "	4
u	$\frac{5}{2}$	552	Avala, Belgrad, Servia	1
S	$\frac{3}{1\,0}\,\frac{2}{5}$	3.4.10	Terlingua, Texas	4

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Carnallite

x	$\infty 2$	120	Königshutter, Germany	2
g	$0\frac{1}{2}$	012	" "	1
h	$0\frac{3}{2}$	032	" "	1
r	$0\frac{8}{3}$	083	" "	2
q	07	071	" "	2
n	$\frac{1}{3}0$	103	" "	1
u	$\frac{1}{8}$	118	" "	1
t	$\frac{1}{4}$	114	" "	1
ι	$\frac{3}{2}$	332	" "	2
w	$\frac{1}{6}\,\frac{1}{3}$	126	" "	1

y	13	131	Königshutter, Germany	2
v	$\frac{1}{6}\,\frac{1}{2}$	136	" "	1

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Cassiterite

λ	$\frac{1}{9}\,0\,\infty$	10.9.0	Selangor, Malay Peninsula	2
	$\infty 4$	140	Cassiterite Creek, Alaska	5
n	6	661	Cornwall, England	1
σ	12	12.12.1	" "	1
s	18	18.18.1	" "	1
g	34	341		3
d	$\frac{3}{2}2$	342	Cornwall, England	1
Θ	$\frac{1}{2}\,1\,\frac{3}{2}$	11.13.2	" "	1
H	$2\frac{1}{4}\,3$	8.13.4	Pitkäranta, Finland	4
K	$2\frac{1}{3}\,0$	6.10.3	" "	4
L	$2\frac{7}{2}$	472	" "	4
M	$2\frac{1}{4}\,5$	8.15.4	" "	4
N	24	241	" "	4
O	$2\frac{9}{2}$	492	" "	4
R	$\frac{1}{6}\,3\,\frac{1}{6}\,7$	13.17.6	" "	4
S	$\frac{1}{5}\,1\,\frac{1}{5}\,4$	11.14.5	" "	4
w	$\frac{1}{7}\,6\,\frac{1}{7}\,9$	16.19.7	" "	4
T	$\frac{7}{3}\,\frac{8}{3}$	783	" "	4

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*6.—L. H. Borgstrom, 1909, Ofver. Finska Vet. Soc. Förh., LIA, p. 2.

Celestite

A_1	$\frac{1}{3}\,0\,\infty$	10.3.0	Dobogó Berg, Hungary	1
F_1	$\infty\frac{5}{4}$	450	Romagna, Italy	5
X_1	$\infty\frac{3}{2}$	230	" "	5
ξ^2	$0\frac{1}{2\,0}$	0.1.20	Salzburg, Germany	2
	$0\frac{1}{1\,6}$	0.1.16	Vicentine Alps, Italy	9
ξ^1	$0\frac{1}{1\,0}$	0.1.10	Salzburg, Germany	2
	$0\frac{1}{9}$	019	Lornano, Siena, Italy	12
	$0\frac{1}{7}$	017	Romagna, Italy	10
	$0\frac{6}{7}$	067		14

	$0\frac{8}{7}$	087?	Romagna, Italy	5
	$0\frac{15}{2}$	0.15.2	Khotin, Bessarabia, Russia	7
	$\frac{1}{17}0$	1.0.17	Tumminelli, Sicily, Italy	15
K_1	$\frac{9}{8}0$	908	Schafenberg, Saxony, Ger.	3
N	$\frac{7}{5}0$	705	Giershagen, Stadberge, Ger.	6
	$\frac{1}{9}$	119	Vicentine Alps, Italy	9
	$\frac{1}{7}$	117	" " "	9
Q	$\frac{3}{2}$	332	Giershagen, Stadtberge, Ger.	6
R	$\frac{1}{19}1$	1.19.19	" " "	6
Y	$\frac{1}{10}1$	1.10.10	Bronseval, Haute Marne, France	4
	$\frac{1}{7}1$	177	Kresty, Saratow, Russia	11
	$\frac{1}{5}1$	155	Scharfenberg, Saxony, Ger.	3
	$\frac{3}{2}1$	322	Strongoli, Calabria, Italy	8
π^1	$\frac{1}{2}\frac{1}{4}$	214	Salzburg, Germany	2
v_1	$\frac{5}{4}\frac{1}{2}$	524	Scharfenberg, Saxony, Ger.	3
e	$\frac{1}{2}\frac{1}{3}$	326	Romagna, Italy	5
	$\frac{3}{7}\frac{2}{7}$	327	Lornando, Siena, Italy	12
	$\frac{3}{8}\frac{1}{4}$	328	Grottacalda, Sicily, Italy	15
ϑ	$\frac{1}{4}\frac{1}{2}$	124	Russia	16
	$\frac{1}{6}\frac{7}{6}$	176	Mokattan, Egypt	13
P	$\frac{5}{2}3$	562	Romagna, Italy	5
	$\frac{9}{8}\frac{5}{8}$	958	Isère, France	17
s	$\frac{2}{9}\frac{10}{9}$	2.10.9	Tunis	18
	$\frac{1}{10}\frac{11}{10}$	1.11.10	"	18

1.—K. Zimányi, 1887, Math. es term. tud. Estestito, VI, p. 84.
2.—L. Buchrucker, 1891, Zeitschr. f. Kryst., XIX, p. 113.
3.—F. Stöber, 1891, Zeitschr. f. Kryst., XIX, p. 437.
4.—F. Stöber, 1893, Zeitschr. f. Kryst., XXI, p. 339.
5.—E. Artini, 1893, Rend. Inst. Lomb., (2) XXVI, p. 333.
6.—A. Arzruni and K. Thaddéeff, 1895, Zeitschr. f. Kryst., XXV, p. 38.
7.—Prendel, 1896, Min. Ges. Petersb., XXXIV, p. 185.
8.—F. Millosevici, 1899, Rend. Accad. Linc, VIII, p. 345.
9.—E. Billows, 1904, Riv. Min. Ital., XXXI, p. 3.
10.—F. Zambonini, 1904, Rend. Accad. Linc., (1) XIII, p. 37.
11.—N. Surgunoff, 1904, Bull. Soc. Nat. Moscow, p. 435.
12.—E. Manasse, 1907, Atti. Soc. Tosc., XXIII.
13.—Couyat, 1907, Compt. Rend., CXLV, p. 504.
14.—A. S. Eakle, 1908, Univ. Cal. Pub. (Geol.), V, p. 225.
15.—E. Traina, 1908, Mem. Accad. Linc., VI, p. 544.
16.—J. Samojlov, 1909, Bull. Ac. St. Petersb., p. 692.
17.—A. Lacroix, 1910, Min. de France, IV, p. 103.
18.—G. Cesáro, 1910, Ann. Soc. Géol. Belg., XXXVIII, p. 23.

Celsian

a: b: c = 0.657:1:0.554 $\beta = 115° 2'$

P	0	001	Jacobsberg, Sweden		1
M	0∞	010	"	"	1
K	∞	110	"	"	1
Y	20	201	"	"	1
	$-\frac{1}{4}$	$\bar{1}14$	"	"	1
G	$-\frac{1}{2}$	$\bar{1}12$	"	"	1
O	—1	$\bar{1}11$	"	"	1
	—3	$\bar{3}31$	"	"	1
	—31	$\bar{3}11$	"	"	1

1.—J. E. Strandmark, 1903, Geol. Fören. Förh., XXXV, p. 289.

Cenosite

a: b: c = 0.9517:1:0.8832

c	0	001	Nordmark, Sweden		1
b	0∞	010	"	"	1
m	∞	110	"	"	1
h	$\infty\frac{3}{2}$	230	"	"	1
f	$0\frac{2}{3}$	023	"	"	1
d	01	011	"	"	1
e	02	021	"	"	1
g	20	201	"	"	1

1.—Hj. Sjögren, 1897, Geol. Fören. Förh., XIX, p. 54.

Cerussite

a: b: c = 0.6102:1:0.7231 (Dubigk)

	3∞	310	Santa Rosalia, Peru		2
b	$\infty\frac{8}{3}$	380	Missoula, Wis.		4
	$\infty\frac{2.5}{8}$	8.25.0	Tsumeb, S. W. Africa		11
	$\infty 5$	150	Santa Rosalia, Peru		2
	$\infty 10$	1.10.0	Tsumeb, S. W. Africa		11
	$\infty 23$	1.23.0	"	"	11
	$\infty 31$	1.31.0	"	"	11
e	$0\frac{2}{5}$	025	Tarnowitz, Silesia, Ger.		3
T	$0\frac{3}{4}$	034	Sardinia		8
	$0\frac{11}{10}$	0.11.10	Tsumeb, S. W. Africa		11
	$0\frac{8}{7}$	087	"	"	11
	$0\frac{7}{6}$	076	"	"	11

Q	$0\frac{5}{4}$	054	Sardinia	8
	$0\frac{9}{5}$	095	Tsumeb, S. W. Africa	11
	$0\frac{3}{2}$	032	Sardinia	1
R	$0\frac{5}{2}$	052	"	1
C	$0\frac{7}{2}$	072	Rézbánya, Hungary	9
B	$0\frac{9}{2}$	092	" "	9
D	$0\frac{1}{2}^{1}$	0.11.2	" "	9
λ	$0\frac{2}{4}^{5}$	0.25.4	Missoula, Wis.	4
M	$0\frac{1}{2}^{3}$	0.13.2	Rézbánya, Hungary	9
	$0\frac{2}{4}^{9}$	0.29.4	Tsumeb, S. W. Africa	11
	0.13	0.13.1	Val Seriana, Italy	5
	0.22	0.22.1	Mies, Bohemia	6
	0.25	0.25.1	" "	6
	0.29	0.29.1	" "	6
	0.33	0.33.1	" "	6
	0.37	0.37.1	" "	6
E	$\frac{1}{4}0$	104	Sardinia	1
A	$\frac{3}{4}0$	304	Mepimi, Mexico	7
	$\frac{6}{7}0$	607	Reichenbach, Baden, Ger.	10
a	4	441	Tarnowitz, Silesia, Ger.	3
u	$\frac{3}{2}$	332	Missoula, Wis.	4
g	17	171	Tarnowitz, Silesia, Ger.	3
H	16	161	Sardinia	1
	$\frac{5}{1}\frac{4}{4}\frac{4}{7}$	5.8.14	Reichenbach, Silesia, Ger.	10

1.—E. Artini, 1889, Rend. Accad. Linc., (4), V, p. 20.
2.—H. Buttgenbach, 1902, Ann. Soc. Géol. Belg., XXIX, p. 103.
3.—H. Traube, 1894, Zeitschr. Geol. Ges., XL, p. 60.
4.—W. H. Hobbs, 1895, Amer. Journ. Sci., L, p. 121.
5.—E. Artini, 1896, Riv. Min. Ital., XVI, p. 21.
6.—H. L. Bravič, 1900, Ber. böhm. Ges. Wiss., XXXVI.
7.—V. Goldschmidt, 1902, Neues Jahrb. f. Min., B.-B., XV, p. 562.
*8.—P. F. Hubrecht, 1905, Zeitschr. f. Kryst., XL, p. 147.
9.—Low, 1908, Földt. Közlöny, XXXVIII, p. 205.
10.—V. Dürrfeld, 1912, Zeitschr. f. Kryst., L, p. 582.
11.—H. Dubigk, 1913, Neues Jahrb. f. Min., B.-B., XXXVI, p. 214.

Chalcanthite

p	$\infty 4$	140	Zajecar, Servia	2
l	$\infty 2$	120	Alameda Co., Calif.	1
d	—20	$20\bar{1}$	Zajecar, Servia	3
o	—1	$1\bar{1}\bar{1}$	" "	3

o^1	—1	$1\bar{1}1$	Zajecar, Servia	2
g	$1\bar{4}$	$1\bar{4}1$	Alameda Co., Calif.	1

1.—W. T. Schaller, 1903, Bull. Univ. Calif. (Geol.), III, p. 212.
2.—V. Rosicky, 1908, Abh. d. böhm. Akad., XIII, No. 28.
3.—O. Haas, 1913, Zeitschr. f. Kryst., LIII, p. 183.

Chalcophyllite

a: c = 1:2.671

x	$\frac{1}{4}0$	$10\bar{1}4$	Bisbee, Ariz.	1
y	—20	$02\bar{2}1$	" "	1

1.—C. Palache and H. E. Merwin, 1909, Amer. Journ. Sci., XXVIII, p. 537.

Chalcocite

	$0\frac{5}{2}$	052	Montecatini, Italy	1

1.—G. Boeris, 1894, Zeitschr. f. Kryst., XXIII, p. 235.

Chalcopyrite

μ	$\frac{2}{5}0$	205	Arakawa, Japan	12
H^1	$\frac{2}{3}0$	203	Andreasberg, Harz, Ger.	5
τ	$\frac{5}{9}0$	509	Pulacayo, Bolivia	8
	$\frac{9}{8}0$	908	Canelas, Durango, Mex.	13
i	$\frac{7}{6}0$	706	Andreasberg, Harz, Ger.	5
τ	$\frac{6}{5}0$	605	Kis-Alamas, Hungary	4
K	$\frac{11}{9}0$	11.0.9	Schemnitz, Hungary	9
Q	$\frac{5}{4}0$	504	Andreasberg, Harz, Ger.	5
M	$\frac{14}{11}0$	14.0.11	Schemnitz, Hungary	9
s	$\frac{9}{7}0$	907	Kis-Alamas, Hungary	4
π	$\frac{4}{3}0$	403	Schemnitz, Hungary	9
ϵ	$\frac{7}{5}0$	705	" "	9
δ	$\frac{10}{7}0$	10.0.7	" "	9
q	$\frac{5}{3}0$	503	Andreasberg, Harz, Ger.	5
χ	$\frac{7}{4}0$	704	Kis-Alamas, Hungary	4
R	$\frac{7}{3}0$	703	Schemnitz, Hungary	9
	$\frac{9}{5}0$	905	Littfeld, Siegen, Ger.	14
L	$\frac{23}{12}0$	23.0.12	Schemnitz, Hungary	9
S	$\frac{5}{2}0$	502	" "	9
	30	301	Canelas, Durango, Mex.	13
	$\frac{11}{3}0$	11.0.3	Val de Villé, Alsace, France	11
T	60	601	Schemnitz, Hungary	9
W	70	701	" "	9
σ	$\frac{1}{12}$	1.1.12?	Redruth, Cornwall, Eng.	7

β	$\frac{1}{8}$	118	Redruth, Cornwall, Eng.	7
γ	$\frac{1}{5}$	115	Visé, Belgium	6
λ	$\frac{2}{9}$	229	Redruth, Cornwall, Eng.	7
d_1	$\frac{1}{4}$	114	Schemnitz, Hungary	9
x	$\frac{1}{3}$	113	Pulacayo, Bolivia	8
	$\frac{5}{8}$	558	Val de Villé, Alsace, France	11
r	$\frac{3}{2}$	332	Andreasberg, Harz, Ger.	5
ρ	$\frac{5}{3}$	553	Redruth, Cornwall, Eng.	7
t	2	221	Andreasberg, Harz, Ger.	5
f	$\frac{5}{2}$	552	Redruth, Cornwall, Eng.	7
φ	$\frac{7}{2}$	772?	French Creek, Chester Co., Pa.	1
F	5	551	Redruth, Cornwall, Eng.	7
η	7	771	Pulacayo, Bolivia	8
μ	11	11.11.1?	Traversella, Italy	10
χ	$\frac{1}{2}1$	122	French Creek, Chester Co., Pa.	1
s	51	511	Schemnitz, Hungary	9
Y	$1\frac{1}{5}$	525	Traversella, Italy	10
F	$-1\frac{1}{4}$	$4\bar{1}4$	Schemnitz, Hungary	9
y	$1\frac{1}{3}$	313	Andreasberg, Harz, Ger.	5
Z	$1\frac{2}{5}$	525	Schemnitz, Hungary	9
s	$-1\frac{2}{3}$	$5\bar{2}5$	Westphalia	2
	$-1\frac{3}{7}$	$7\bar{3}7$	Canelas, Durango, Mex.	13
	$\frac{3}{2}\,\frac{1}{2}$	312	Burgholdingshaven, Siegen, Ger.	3
	$\frac{5}{4}\,\frac{3}{4}$	534	" " "	3
N	$-\frac{3}{4}\,\frac{1}{12}$	$9.\bar{1}.12$	Schemnitz, Hungary	9
H	$-\frac{5}{4}\,\frac{1}{10}$	$8.\bar{1}.10$	" "	9
G	$\frac{10}{7}\,\frac{4}{7}$	10.4.7	" "	9
ω	$\frac{5}{6}\,\frac{7}{6}$	576	French Creek, Chester Co., Pa.	1

1.—S. L. Penfield, 1890, Amer. Journ. Sci., XL, p. 207.
2.—G. Cesáro, 1894, Bull. Ac. Belg., XXVIII, p. 182.
3.—Sonheur, 1894, Zeitschr. f. Kryst., XIII, p. 545.
4.—K. Zimányi, 1896, Zeitschr. f. Kryst., XXVII, p. 95.
5.—O. Luedecke, 1896, Min. d. Harzes, p. 113.
6.—H. Buttgenbach, 1898, Ann. Soc. Géol. Belg., p. 25.
7.—W. J. Lewis and A. L. Hall, 1900, Min. Mag., XII, p. 324.
8.—Z. Toborffy, 1904, Zeitschr. f. Kryst., XXXIX, p. 366.
9.—B. Mauritz, 1905, Zeitschr. f. Kryst., XL, p. 589.
10.—L. Colomba, 1905, Rend. Accad. Linc., (5) XV.
11.—H. Ungemach, 1906, Bull. Soc. fr. Min., XXIX, p. 194.
12.—J. Beckenkamp, 1907, Zeitschr. f. Kryst., XLIII, p. 43.
13.—H. Ungemach, 1910, Bull. Soc. fr. Min., XXXIII.
14.—J. F. Oebike, 1915, Inaug. Diss. Münster, i. Westf., p. 56.

Chalcostibite

$a:b:c = 0.5283:1:0.6364$

c	0	001	Wolfsberg, Harz, Ger.	1
b	0∞	010	" " "	1
l	$\infty 3$	130	Huanchaca, Bolivia	4
f	01	011	Wolfsberg, Harz, Ger.	1
s	$0\frac{6}{5}$	065	Huanchaca, Bolivia	4
t	02	021	Wolfsberg, Harz, Ger.	1
u	06	061	" " "	1
Δ	$\frac{2}{9}0$	209	Huanchaca, Bolivia	4
Δ_1	$\frac{2}{7}0$	207	" "	4
Δ_2	$\frac{1}{3}0$	103	" "	4
e	$\frac{3}{7}0$	307	Wolfsberg, Harz, Ger.	2
j	$\frac{1}{2}0$	102	Huanchaca, Bolivia	4
h	$\frac{2}{3}0$	203	Wolfsberg, Harz, Ger.	1
d	10	101	" " "	1
i	$\frac{3}{2}0$	302	" " "	1
g	20	201	" " "	1
v	$\frac{1}{3}1$	133	Huanchaca, Bolivia	4
α	$\frac{2}{3}1$	233	" "	3
μ	$\frac{1}{6}\ \frac{1}{2}$	136	" "	4
r	$\frac{1}{4}\ \frac{3}{4}$	134	Wolfsberg, Harz, Ger.	2
π	$\frac{2}{5}\ \frac{6}{5}$	265	Huanchaca, Bolivia	4
ρ	$\frac{2}{3}2$	263	" "	4
σ	$\frac{4}{5}\ 1\frac{2}{5}$	4.12.5	" "	4
τ	26	261	" "	4
p	$\frac{6}{7}\ 1\frac{2}{7}$	6.72.7	Wolfsberg, Harz, Ger.	2
γ	$1\frac{7}{4}$	474	Huanchaca, Bolivia	3
δ	$\frac{4}{5}\ \frac{7}{5}$	475	" "	3
ϵ	$\frac{2}{3}\ \frac{7}{6}$	476	" "	3
β	$\frac{3}{4}\ \frac{5}{4}$	354	" "	3
q	$\frac{8}{3}2$	863	Wolfsberg, Harz, Ger.	2

1.—C. Friedel, 1879, Bull. Soc. fr. Min., II, p. 203.
2.—H. Laspeyres, 1891, Zeitschr. f. Kryst., XIX, p. 428.
3.—L. J. Spencer, 1896, London Min. Soc.
4.—S. L. Penfield and A. Frenzel, 1897, Amer. Journ. Sci., IV, p. 27.

[Note: Friedel's indices are transposed to correspond with the position adopted by Lespeyres.]

Chalmersite

$a:b:c = 0.5822:1:0.5611$

c	0	001	Minas Gereas, Brazil			1
a	$\infty 0$	010	"	"	"	1
b	0∞	100	"	"	"	1
d	2∞	210	"	"	"	3
l	∞	110	"	"	"	1
r	$\infty 2$	120	"	"	"	1
m	$\infty 3$	130	"	"	"	3
y	01	011	"	"	"	3
f	$\frac{1}{2}0$	102	"	"	"	3
q	10	101	"	"	"	1
p	13	131	"	"	"	4
w	1	111	"	"	"	4
s	2	221	"	"	"	3
t	$\frac{1}{2}$	112	"	"	"	3
o	$\frac{1}{2}1$	122	"	"	"	3
v	$\frac{1}{2}\frac{3}{2}$	132	"	"	"	4
u	$\frac{3}{4}\frac{1}{4}$	314	"	"	"	3

1.—E. Hussak, 1902, Centralb. f. Min., p. 69; 1906, idem., p. 332.
2.—F. Rinne, 1902, Centralb. f. Min., p. 207.
3.—C. Palache, 1907, Amer. Journ. Sci., XXIV, p. 255.
4.—C. Hlawatsch, 1910, Zeitschr. f. Kryst., XLVIII, p. 205.

Childrenite

u	$\infty 4$	140				1

1.—F. Slavic, 1914, Abh. d. böhm. Akad., No. 4.

Chillagite

Tetragonal $a:c = 1:1.5291$

c	0	001	Chillagoe, Queensland, Austr.			1
i	$0\frac{1}{3}$	013	"	"	"	1
e	01	011	"	"	"	1
Θ	$0\frac{3}{2}$	032	"	"	"	1
X	$0\frac{9}{4}$	094	"	"	"	1
Y	$\frac{1}{1\,8}$	1.1.18	"	"	"	1
S	$\frac{1}{1\,0}$	1.1.10	"	"	"	1
y	$\frac{1}{9}$	119	"	"	"	1
Z	$\frac{2}{1\,7}$	2.2.17	"	"	"	1
l	$\frac{1}{8}$	118	"	"	"	1

k	$\frac{1}{7}$	117	Chillagoe, Queensland, Austr.			1
g	$\frac{1}{6}$	116	"	"	"	1
G	$\frac{2}{1\,1}$	2.2.11	"	"	"	1
F	$\frac{3}{1\,6}$	3.3.16	"	"	"	1
f	$\frac{1}{5}$	115	"	"	"	1
d	$\frac{1}{4}$	114	"	"	"	1
D	$\frac{6}{2\,3}$	6.6.23	"	"	"	1
b	$\frac{1}{3}$	113	"	"	"	1
w	$\frac{2}{5}$	225	"	"	"	1
p	1	111	"	"	"	1
z	$\frac{2}{7}1$	277	"	"	"	1
π	$\frac{1}{3}1$	133	"	"	"	1
x	$1\frac{4}{3}$	343	"	"	"	1

1.—Miss C. D. Smith and L. A. Cotton, 1912, Journ. Roy. Soc. N. S. Wales, XLVI, p. 207.

Chlormanganokalite

Hexagonal Rhombohedral $a:c=1:0.5801$

a	$11\bar{2}0$	Vesuvius, Italy		1
r	$10\bar{1}0$	"	"	1

1.—H. J. Johnston-Lavis and L. J. Spencer, 1908, Min. Mag., XV, p. 54.

Chrysoberyl

t	$\frac{1\,1}{3}\infty$	11.3.0	New York City	4
l	2∞	210	Ceylon	1
g	$\infty\frac{7}{3}$	370	New York City	4
q	$\infty 4$	140	Ceylon	1
h	$\infty 5$	150	"	2
π	13	131	"	3
p	$1\frac{3}{2}$	232	"	1
h	$1\frac{1}{3}$	313	"	1
g	$1\frac{1}{5}$	515	"	1
f	$1\frac{1}{1\,0}$	10.1.10	"	1
τ	$\frac{2}{7}1$	277	"	3
l	$\frac{1}{3}1$	133	"	2
Ψ	$\frac{1\,1}{2\,0}1$	11.20.20	"	3
α	31	311	"	2
β	51	511	"	2
η	$\frac{1}{3}$	113	"	3
Q	$\frac{1}{2}2$	142	"	2

φ	$\frac{1}{9}2$	1.18.9	Ceylon	3
w	$\frac{7}{8}\ \frac{5}{4}$	7.10.8	"	3

1.—G. Melczer, 1900, Zeitschr. f. Kryst., XXXIII, p. 240.
2.—V. Goldschmidt and H. Preiswerk, 1900, Zeitschr. f. Kryst., XXXIII, p. 455.
3.—A. Liffa, 1902, Zeitschr. f. Kryst., XXXVI, p. 606.
4.—H. P. Whitlock, 1912, N. Y. State Mus., Bull. CLVIII, p. 185.

Chrysolite

t	$\infty\frac{3}{2}$	230	Latium, Italy	1
w	14	141	" "	1

1.—F. Zambonini, 1899, Zeitschr. f. Kryst., XXXII, p. 152.

Cinnabar

I	$\frac{1}{2}$	$11\bar{2}2$	Alsósajó, Hungary	1
j	$\frac{5}{8}0$	$50\bar{5}8$	" "	1
A	$\frac{8}{9}0$	$80\bar{8}9$	" "	1
X	$\frac{9}{8}0$	$90\bar{9}8$	" "	1
V	$\frac{8}{5}0$	$80\bar{8}5$	" "	1
Y	$\frac{11}{4}0$	$11.0.\bar{11}.4$	" "	1

1.—K. Zimányi, 1906, Zeitschr. f. Kryst., XLI, p. 439.

Clinohedrite

$a:b:c=0.68245:1:0.3226 \quad \beta=76°\ 2\frac{1}{2}'$

b	0∞	010	Franklin Furnace, N. J.	1
h	$\frac{3}{2}\infty$	320	" " "	1
m	∞	110	" " "	1
m_1	$-\infty$	$\bar{1}10$	" " "	1
n	$\infty 2$	120	" " "	1
l	$\infty 3$	130	" " "	1
e	$+10$	101	" " "	1
e_1	-10	$\bar{1}01$	" " "	1
p	$+1$	111	" " "	1
p_1	$1\bar{1}$	$\bar{1}1\bar{1}$	" " "	1
q	$\bar{1}1$	$\bar{1}11$	" " "	1
q_1	$\bar{1}\bar{1}$	$11\bar{1}$	" " "	1
r	-3	$\bar{3}31$	" " "	1
s	-5	$\bar{5}51$	" " "	1
t	-7	$\bar{7}71$	" " "	1
u	-53	$\bar{5}31$	" " "	1
o	13	131	" " "	1

o_1	—13	$13\bar{1}$	Franklin Furnace, N. J.	1
x	$1\bar{3}$	$\bar{1}3\bar{1}$	" " "	1
y	$1\bar{2}$	$\bar{1}2\bar{1}$	" " "	1

1.—S. L. Penfield and H. W. Foote, 1898, Amer. Journ. Sci., V, p. 289.

Cobaltnickelpyrite

Isometric Pyritohedral

0	001	Musen, Germany	1
$0\frac{2}{3}$	023	" "	1
1	111	" "	1

1.—M. Henglein, 1913, Centralb. f. Min., p. 129.

Colemanite

$a:b:c = 0.7768:1:0.5430 \quad \beta = 110°\ 7'$

l	3∞	310	San Bernardino Co., Calif.	1
ρ	+30	301	" " "	1
g	$-\frac{5}{2}0$	$\bar{5}02$	" " "	1
f	—80	$\bar{8}01$	" " "	1

1.—A. S. Eakle, 1902, Bull. Univ. Calif., (Geol.), III, p. 31.

Columbite

r	14	141	San Diego Co., Calif.	1

1.—A. S. Eakle, 1907, Bull. Univ. Calif., (Geol.), V, p. 87.

Copper

$\frac{3}{2}\infty$	320	Westphalia	1
$\frac{11}{10}\infty$	11.10.0	"	1
$\frac{7}{2}1$	722	"	1
$\frac{3}{2}1$	322	"	1

1.—J. F. Oebike, 1915, Inaug. Diss. Münster, i. Westf., p. 56.

Cordylite

Hexagonal $a:c = 1:3.3865$

c	0	0001	Narsarsuk, Greenland	1
m	$\infty 0$	$10\bar{1}0$	" "	1
q	$\frac{1}{3}0$	$10\bar{1}3$	" "	1
p	$\frac{4}{15}0$	$4.0.\bar{4}.15$	" "	1
r	$\frac{2}{3}0$	$20\bar{2}3$	" "	1
s	$\frac{4}{3}0$	$40\bar{4}3$	" "	1

1.—G. Flink, 1898, Medd. om Grönland, XIV, p. 236.

CORUNDUM

	$\frac{5}{2}\,\infty$	$52\bar{7}0$	Burma-Ceylon	5
e	$3\,\infty$	$31\bar{4}0$	Burma	7
	$\frac{1}{10}0$	$1.0.\bar{1}.10$	Burma-Ceylon	5
r	$-\frac{1}{2}0$	$01\bar{1}2$	Burma	2
	$\frac{4}{5}0$	$40\bar{4}5$	Burma-Ceylon	5
	$\frac{7}{8}0$	$70\bar{7}8$	" "	5
	$\frac{6}{5}0$	$60\bar{6}5$	" "	5
	$\frac{3}{2}0$	$30\bar{3}2$	Ceylon	7
x	50	$50\bar{5}1$	"	6
ϑ	80	$80\bar{8}1$	Cashmere	6
	$\frac{5}{7}$	$5.5.\bar{1}0.7$	Burma-Ceylon	5
	$\frac{10}{9}$	$10.10.\bar{2}0.9$	Vontovorona, Madegascar	8
	$\frac{5}{4}$	5.5.10.4	Utal Mts., Russia	3
τ	$\frac{11}{9}$	$11.11.\bar{2}2.9$	Cashmere	4
t	$\frac{3}{2}$	$33\bar{6}2$	Ceylon	7
	$\frac{5}{3}$	$5.5.\bar{1}0.3$	Burma-Ceylon	5
σ	$\frac{8}{5}$	$8.8.\bar{1}6.5$	Cashmere?	4
	$\frac{11}{6}$	$11.11.\bar{2}2.6$	Ceylon	1
Θ	$\frac{8}{3}$	$8.8.\bar{1}6.3$	Vontovorona, Madegascar	8
	$\frac{13}{6}$	$13.13.\bar{2}6.6$	Cashmere?	4
λ	$\frac{7}{3}$	$7.7.\bar{1}4.3$	Vontovorona, Madegascar	8
ξ	$\frac{5}{2}$	$5.5.\bar{1}0.2$	Cashmere?	4
u	3	$33\bar{6}1$	"	4
	$\frac{10}{3}$	$10.10.\bar{2}0.3$	Vontovorona, Madegascar	8
	$\frac{7}{2}$	$7.7.\bar{1}4.2$	Burma-Ceylon	5
ϵ	$\frac{11}{3}$	$11.11.\bar{2}2.3$	Cashmere?	4
ω	$\frac{14}{3}$	$14.14.\bar{2}8.3$	Vontovorona, Madegascar	8
p	5	$5.5.\bar{1}0.1$	Ceylon	6
p^1	-5	$10.\bar{5}.\bar{5}.1$	"	6
	$\frac{11}{2}$	$11.11.\bar{2}2.2$	Burma-Ceylon	5
ι	21	$21\bar{3}1$	Ceylon	6
ξ	$\frac{5}{2}1$	$52\bar{7}2$	"	7
φ	41	$41\bar{5}1$	"	6
B	91	$9.1.\bar{1}0.1$	"	7
ψ	$\frac{5}{3}\,\frac{1}{3}$	$51\bar{6}3$	"	7
h	$\frac{8}{5}\,\frac{4}{5}$	$8.4.\bar{1}2.5$	"	7
s	$\frac{10}{3}\,\frac{5}{3}$	$10.5.\bar{1}5.3$	"	7
D	$\frac{4}{3}\,\frac{9}{8}$	$12.8.\bar{2}0.9$	"	7

φ_1	14	$14\bar{5}1$	Ceylon	6
χ	28	$2.8.\bar{10}.1$	"	6

1.—R. Busz, 1889, Zeitschr. f. Kryst., XV, p. 622.
2.—M. Bauer, 1896, Neues Jahrb. f. Min., II, p. 197.
3.—H. Barvíř, 1897, Ann. Mus. Wein, VII, p. 135.
4.—H. L. Bowman, 1900, Min. Mag., XII, p. 355.
5.—G. Melczer, 1902, Zeitschr. f. Kryst., XXXV, p. 561.
6.—A. Nies and V. Goldschmidt, 1908, Neues Jahrb. f. Min., II, p. 97.
7.—V. Goldschmidt and R. Schroeder, 1910, Min. u. Petro. Mitth., XXIX, p. 461.
8.—H. Ungemach, 1916, Bull. Soc. fr. Min., XXXIX.

Covellite

$a:b:c = 0.5746:1:0.6168 \quad \beta = 90° 46'$

c	0	001	Bor. Serbia	1
	$0\frac{1}{6}$	016	" "	1
	$0\frac{1}{4}$	014	" "	1
	$0\frac{1}{3}$	013	" "	1
	$0\frac{2}{5}$	025	" "	1
k	$0\frac{1}{2}$	012	" "	1
	$0\frac{3}{5}$	035	" "	1
	$0\frac{2}{3}$	023	" "	1
r	$0\frac{3}{4}$	034	" "	1
	$0\frac{3}{5}$	035	" "	1
	$0\frac{4}{5}$	045	" "	1
s	01	011	" "	1
	$0\frac{5}{4}$	054	" "	1
t	$0\frac{4}{3}$	043	" "	1
g	$0\frac{3}{2}$	032	" "	1
	$0\frac{8}{5}$	085	" "	1
	$0\frac{5}{3}$	053	" "	1
	$0\frac{7}{4}$	074	" "	1
	$0\frac{9}{5}$	095	" "	1
l	02	021	" "	1
	$0\frac{8}{3}$	083	" "	1
d	03	031	" "	1
	$0\frac{13}{4}$	0.13.4	" "	1
f	04	041	" "	1
h	$0\frac{9}{2}$	092	" "	1
i	05	051	" "	1
	06	061	" "	1
y	$0\frac{15}{2}$	0.15.2	" "	1

z	08	081	Bor. Serbia	1
v	09	091	" "	1
w	0.16	0.16.1	" "	1
p	1	111	" "	1

1.—S. Stevanovic, 1908, Zeitschr. f. Kryst., XLIV, p. 349.

Crocoite

S	$\frac{1}{3}^{0}\,\infty$	10.3.0	Dundas, Tasmania	1
T	$\frac{5}{3}\,\infty$	530	" "	1
f	$\infty\,\frac{7}{4}$	470	" "	5
J	$0\frac{3}{2}$	032	" "	4
	$\frac{4}{3}0$	403	Penchalonga, Mashonaland, S. Africa	2
x	—30	$\bar{3}01$	Dundas, Tasmania	3
Θ	3	331	" "	3

1.—C. Palache, 1896, Amer. Journ. Sci., I, p. 389.
2.—K. Redlich, 1896, Zeitschr. f. Kryst., XXVIII, p. 607.
3.—G. Moesz, 1899, Zeitschr. f. Kryst., XXXIV, p. 707.
4.—R. G. Van Name, 1902, Amer. Journ. Sci., XIII, p. 339.
5.—F. Slavic, 1904, Zeitschr. f. Kryst., XXXIX, p. 302.

Cryolite

$0\,\infty$	010	Ivigtuk, Greenland	1
$0\frac{1}{2}$	012	" "	1
$0\frac{1}{5}$	015	" "	1
$\frac{1}{2}0$	102	" "	1
$\frac{1}{5}0$	105	" "	1
$-\frac{1}{2}0$	$\bar{1}02$	" "	1
$-\frac{1}{2}$	$\bar{1}12$	" "	1
$\frac{2}{5}\,\frac{7}{5}$	$\bar{2}75$	" "	1
$\frac{7}{5}\,\frac{2}{5}$	725	" "	1

1.—O. B. Böggild, 1911, Medd. om Grönland, L,

Cumengite

a: c = 1:1.625

0	001	Boleo, Lower California, Mex.			1
∞	110	"	"	"	" 1
10	101	"	"	"	" 1

1.—G. Freidel, 1906, Bull. Soc. fr. Min., XXIX, p. 14.

Cuprite

	$\frac{6}{5}$	665	Kausen, Westphalia, Ger.	2
	27	27.27.1	" " "	2
	$\frac{6}{5}1$	655	" " "	2
	$\frac{5}{3}1$	533	Wheal Phoenix, Liskeard, Eng.	1

1.—H. A. Miers, 1889, Min. Mag., VIII, p. 204.
2.—J. F. Oebike, 1915, Inaug. Diss. Münster, i. Westf., p. 56.

Cuspidine

u	$\infty 2$	120	Alban Mts., Italy	1
l	12	121	" " "	1

1.—F. Stella Starrabba, 1913, Rend. Accad. Linc., (5) XXII, p. 871.

Cyanite

t	$\frac{5}{2}\infty$	520	Yancy Co., N. C.	1

1.—J. H. Pratt, 1898, Amer. Journ. Sci., V, p. 181.

Danburite

m	3∞	310	Obira, Japan	3
v	$\infty\frac{9}{5}$	590	Piz Giuf, Sedrun, Ubi, Switz.	2
	0.50	0.50.1	Takachio, Hiuga, Japan	1
	0.29	0.29.1	" " "	1
	0.23	0.23.1	" " "	1
	$0\frac{3}{5}\frac{1}{5}$	0.31.5	" " "	1
	$0\frac{2}{5}\frac{2}{5}$	0.22.5	" " "	1
	$0\frac{1}{3}\frac{0}{3}$	0.10.3	Japan	4
χ	$\frac{3}{2}0$	302	Obira, Japan	3
n	$\frac{5}{2}0$	502	" "	3
P	$\frac{1}{3}\frac{1}{3}0$	11.0.3	" "	3
Q	$\frac{9}{2}0$	902	" "	3
R	60	601	" "	3
	16.0	16.0.1	Takachio, Hiuga, Japan	1
S	$1\frac{1}{3}$	313	Obira, Japan	3
	$1\frac{3}{5}$	535	Japan	4
ϵ	$\frac{2}{3}$	223	Takachio, Hiuga, Japan	1
λ	$\frac{1}{2}2$	142	Piz Giuf, Sedrun, Ubi, Switz.	2
U	$\frac{1}{2}\frac{3}{4}$	234?	Obira, Japan	3
Z	$\frac{3}{5}\frac{2}{5}$	325	" "	3
η	26	261	Takachio, Hiuga, Japan	1
V	$\frac{3}{2}\frac{1}{4}$	614	Obira, Japan	3

γ	$\frac{2}{5}\,\frac{1}{10}$	4.1.10	Takachio, Hiuga, Japan		1
Θ	$\frac{5}{8}\,\frac{9}{2}$	5.36.8	"	"	1
	$\frac{10}{19}2$	10.38.19	"	"	1
ω	$\frac{9}{10}2$	9.20.10	Piz Giuf, Sedrun, Ubi, Switz.		2

1.—M. Weber, 1903, Zeitschr. f. Kryst., XXXVII, p. 620.
2.—J. Koenigsberger, 1905, Centralb. f. Min., p. 377.
*3.—V. Goldschmidt and H. Philipp, 1912, Zeitschr. f. Kryst., L, p. 443.
4.—H. Ungemach, 1912, Mém. Soc. Belg., XXXIX, p. 419.

Darapskite

$a:b:c = 1.5258:1:0.7514 \quad \beta = 77°\ 5'$

c	0	001	Atacama, Chile		1
a	$\infty 0$	100	"	"	1
b	0∞	010	"	"	1
m	∞	110	"	"	1
q	01	011	"	"	1
r	10	101	"	"	1
n	—10	$\bar{1}01$	"	"	1
e	$\frac{3}{2}0$	302	"	"	1
d	—20	$\bar{2}01$	"	"	1
o	1	111	"	"	1
s	—1	$\bar{1}11$	"	"	1
v	12	121	"	"	1

1.—A. Osann, 1894, Zeitschr. f. Kryst., XXIII, p. 584.

Dawsonite

$a:b:c = 0.6475:1:0.5339$

C	0	001	Montreal, Can.		1
A	$\infty 0$	100	"	"	1
B	0∞	010	"	"	1
M	∞	110	"	"	1
D	01	011	"	"	1
	2∞	210?	"	"	1
	$\infty\frac{3}{2}$	230?	"	"	1
	$\infty 3$	130?	"	"	1
	10	101?	"	"	1

1.—R. P. D. Graham, 1908, Trans. Roy. Soc. Can., (3) II, p. 165.

Datolite

[Dana Orientation]

s	$\frac{5}{3}\infty$	530	Westfield, Mass.		10
Θ	$\infty 4$	140	"	"	10

n_z	$0\frac{1}{10}$	0.1.10	Westfield, Mass.	5
m_y	$0\frac{6}{7}$	067	" "	5
N	$0\frac{4}{3}$	043	North Plainfield, N. J.	11
q:	70	701	Franklin Furnace, N. J.	7
y	60	601	Westfield, Mass.	10
	$-1\frac{1}{2}0$	$\bar{1}1.0.2$	" "	10
τ	$-\frac{7}{2}0$	$\bar{7}02$	Lake Superior, Mich.	1
$\dot{\imath}$	$\frac{5}{2}0$	502	Westfield, Mass.	10
Σ	$-\frac{3}{2}0$	$\bar{3}02$	Guanajuato, Mexico	2
I	$\frac{3}{4}0$	304	Franklin Furnace, N. J.	7
$\mathfrak{H}$	$\frac{3}{8}0$	308	Westfield, Mass.	9
k	$\frac{3}{10}0$	3.0.10	" "	10
	$\frac{7}{2}1$	722	Markirch, Alsace, France	6
	31	311	" " "	6
$\mathfrak{B}$	21	211	Lake Superior, Mich.	1
$\mathfrak{G}$	$-\frac{7}{3}$	$\bar{7}73$	" " "	1
P	$-\frac{3}{2}$	$\bar{3}32$	Westfield, Mass.	9
μ_1	$-\frac{2}{7}$	$\bar{2}27$	Listic, Bohemia	3
m_z	$-\frac{1}{10}$	$\bar{1}.1.10$	Westfield, Mass.	5
$\mathfrak{V}$	$1\frac{1}{3}$	313	" "	9
$\mathfrak{K}$	$1\frac{5}{4}$	454	" "	9
$\mathfrak{F}$	13	131	" "	9
Y	$\frac{2}{5}1$	255	Erie Cut, Bergen Hill, N. J.	8
$\mathfrak{y}$	$-\frac{9}{2}1$	$\bar{9}22$	Westfield, Mass.	9
d	$\frac{2}{3}2$	263	Franklin Furnace, N. J.	7
k	$\frac{1}{2}\frac{3}{2}$	132	Erie Cut, Bergen Hill, N. J.	8
	$-\frac{1}{4}\frac{3}{4}$	$\bar{1}34$	Markirch, Alsace, France	6
	$-\frac{1}{5}\frac{3}{5}$	$\bar{1}35$	" " "	6
Ξ	$-\frac{1}{3}\frac{1}{2}$	$\bar{1}36$	Westfield, Mass.	10
ϵ^1	$-\frac{1}{8}\frac{1}{2}$	$\bar{1}48$	" "	4
λ^1	$-\frac{1}{9}\frac{4}{9}$	$\bar{1}49$	" "	4
μ^1	$-\frac{1}{10}\frac{2}{5}$	$\bar{1}.4.10$	" "	4
κ:	$-\frac{2}{5}\frac{4}{5}$	$\bar{2}45$	Franklin Furnace, N. J.	7
$\mathfrak{N}$	$-\frac{1}{6}\frac{1}{3}$	$\bar{1}26$	Westfield, Mass.	9
	23	231	Markirch, Alsace, France	6
k.	$\frac{4}{5}\frac{7}{5}$	475	Franklin Furnace, N. J.	7
I	$2\frac{1}{2}$	412	Westfield, Mass.	10
$\mathfrak{B}$	42	421	Andreasberg, Harz, Germany	9
$\mathfrak{U}$	$1\frac{2}{5}2$	12.10.5	" " "	9
Φ	$-\frac{5}{6}\frac{2}{3}$	$\bar{5}46$	Westfield, Mass.	10
	$\frac{5}{8}\frac{1}{2}$	548	Lake Superior, Mich.	1

1.—O. Osann, 1895, Zeitschr. f. Kryst., XXIV, p. 5.
2.—O. C. Farrington, 1898, Amer. Journ. Sci., V, p. 285.
3.—F. Slavic and J. Fišer, 1903, Centralb. f. Min., p. 229.
4.—H. P. Whitlock, 1905, N. Y. State Mus., Bull., XCVIII, p. 19.
5.—E. H. Kraus and C. W. Cook, 1906, Amer. Journ. Sci., XXII, p. 21.
6.—H. Ungemach, 1909, Bull. Soc. fr. Min., XXXII, p. 397.
7.—C. Palache, 1910, Amer. Journ. Sci., XXIX, p. 185.
8.—H. P. Whitlock, 1910, School of Mines Quar., XXXI, p. 225.
*9.—R. Gorgey and V. Goldschmidt, 1910, Zeitschr. f. Kryst., XLVIII, p. 619.
10.—H. Ungemach, 1911, Zeitschr. f. Kryst., XLIX, p. 459.
11.—A. C. Hawkins, 1915, Amer. Journ. Sci., XXXIX, p. 473.

Delafossite

Hexagonal Rhombohedral $a: c = 1:1.94\pm$

0	0001	Bisbee, Ariz.		1
$\infty 0$	$10\bar{1}0$	"	"	1
10	$10\bar{1}1$	"	"	1
$\frac{1}{4}0$	$10\bar{1}4$?	"	"	1
$-\frac{1}{2}0$	$01\bar{1}2$?	"	"	1

1.—A. F. Rogers, 1913, Amer. Journ. Sci., XXXV, p. 290.

Delorenzite

$a: b: c = 0.3375:1:0.3412$

a	$\infty 0$	100	Graveggia, Piedmont, Italy		1
b	0∞	010	"	"	" 1
m	∞	110	"	"	" 1
d	2∞	210	"	"	" 1
g	$\infty 3$	130?	"	"	" 1
s	1	111	"	"	" 1

1.—F. Zambonini, 1908, Zeitschr. f. Kryst., XLV, p. 26.

Descloizite

	3∞	310	Broken Hill, N. W. Rhodesia	1

1.—L. J. Spencer, 1908, Min. Mag., XV, p. 31.

Diamond

d	$0\frac{4}{5}$	045	Southwest Africa	4
n	$\frac{2}{3}$	223	Kimberley, S. Africa	5
X	$\frac{2}{7}1$	277	Transvaal, S. Africa	3
	$\frac{2}{5}1$	255	" "	3
Z	$\frac{1}{5}\frac{3}{5}$	135	" "	2
Ξ	$\frac{1}{7}\frac{3}{7}$	137	Taiga	3

θ	$\frac{1}{9}\ \frac{7}{9}$	179	Ural Mts., Russia	1
	$\frac{1}{64}\ \frac{63}{64}$	1.63.64	Transvaal, S. Africa	3

1.—P. Jeremejeff, 1896, Verh. russ. Min. Ges., XXXIV, p. 59.
2.—P. Jeremejeff, 1897, Verh. russ. Min. Ges., XXXV, p. 31.
3.—P. Jeremejeff, 1899, Verh. russ. Min. Ges., XXXVI, p. 34.
4.—E. Kaiser, 1909, Centralb. f. Min., p. 231.
5.—A. von Fersmann and V. Goldschmidt, 1911, Der Diamant, Heidelberg.

Diaspore

d	03	031	Ovre Arö, Langesund, Norway	1
s	$1\frac{1}{2}$	212	Chester, Mass.	2
d	$\frac{4}{5}1$	455	" "	2
g	$\frac{7}{8}1$	788	" "	2

1.—G. Flink, 1898, Bull. Geol. Inst. Upsala, IV, p. 63.
2.—C. Palache and H. O. Wood, 1909, Proc. Amer. Acad., XLIV, p. 641.

Didymolite

a: b: c = 0.6006:1:0.2867 $\beta = 74°$

	0∞	010	Tatarka River, Yenisei, Siberia			1
	∞	110	"	"	"	" 1
	01	011	"	"	"	" 1

1.—A. Meister, 1908, Verh. Min. Ges., XXXVI, p. 151.

Dietzeite

a: b: c = 1.3826:1:0.9515 $\beta = 73° 28'$

c	0	001	Atacama, Chile	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
l	2∞	210	" "	1
m	∞	110	" "	1
u	—10	$\bar{1}01$	" "	1
s	$-\frac{2}{3}$	$\bar{2}23$	" "	1
o	—2	221	" "	1

1.—A. Osann, 1894, Zeitschr. f. Kryst., XXIII, p. 588.

Dolerophanite

a: b: c = 1.3042:1:1.2100 $\beta = 108° 14'$

μ	70	701	Åvidaberg, Sweden	1

1.—J. E. Standmark, 1902, Geol. Fören. Förh., XXIV, p. 80.

Dolomite

F	$\frac{4}{3}\ \frac{1}{3}$	$41\bar{5}3$	Gébroulaz Glacier, Savoie, France	1
Γ	—12.4	$4.12.\bar{16}.1$	" " " "	1
χ	$5\frac{5}{2}$	$10.5.\bar{15}.2$	Sulzbach, Saar, Germany	2

1.—F. Becke, 1890. Min. u. petro. Mitth., XI, p. 536.
2.—F. Slavic, 1912, Abh. d. böhm. Akad., No. 16, p. 9.

Dufrenoysite

$a:b:c=0.6509:1:0.6125 \quad \beta=89°\ 26\frac{1}{2}'$

$14\,\infty$	14.1.0	Binnenthal, Switzerland	1
$6\,\infty$	610	" "	1
$4\,\infty$	410	" "	1
$\frac{7}{2}\,\infty$	720	" "	2
$3\,\infty$	310	" "	1
$2\,\infty$	210	" "	1
$\frac{7}{4}\,\infty$	740	" "	2
$\frac{5}{3}\,\infty$	530	" "	1
$\frac{3}{2}\,\infty$	320	" "	2
$\frac{7}{5}\,\infty$	750	" "	2
$\frac{4}{3}\,\infty$	430	" "	1
$\frac{7}{6}\,\infty$	760	" "	1
$\frac{1}{1}\frac{2}{1}\,\infty$	12.11.0	" "	1
$\infty\,\frac{1}{1}\frac{2}{1}$	11.12.0	" "	1
$\infty\,\frac{7}{6}$	670	" "	1
$\infty\,\frac{6}{5}$	560	" "	1
$\infty\,\frac{4}{5}$	450	" "	1
$\infty\,\frac{4}{3}$	340	" "	1
$\infty\,\frac{7}{5}$	570	" "	1
$\infty\,\frac{3}{2}$	230	" "	1
$\infty\,\frac{8}{5}$	580	" "	1
$\infty\,\frac{3}{5}$	350	" "	1
$\infty\,\frac{7}{4}$	470	" "	1
$\infty\,\frac{9}{5}$	590	" "	1
$\infty\,2$	120	" "	1
$\infty\,\frac{9}{4}$	490	" "	1
$\infty\,\frac{5}{2}$	250	" "	1
$\infty\,3$	130	" "	1
$\infty\,\frac{7}{2}$	270	" "	1
$\infty\,5$	150	" "	1

$\infty 14$	1.14.0	Binnenthal, Switzerland		1
$0\frac{1}{6}$	016	"	"	1
$0\frac{1}{5}$	015	"	"	1
$0\frac{1}{4}$	014	"	"	1
$0\frac{2}{7}$	027	"	"	2
$0\frac{1}{3}$	013	"	"	2
$0\frac{2}{5}$	025	"	"	2
$0\frac{4}{9}$	049	"	"	2
$0\frac{4}{7}$	047	"	"	2
$0\frac{3}{5}$	035	"	"	1
$0\frac{3}{4}$	034	"	"	1
$0\frac{5}{6}$	056	"	"	1
$0\frac{7}{6}$	076	"	"	3
$0\frac{5}{4}$	054	"	"	1
$0\frac{4}{3}$	043	"	"	1
$0\frac{3}{2}$	032	"	"	1
$0\frac{1}{7}^{1}$	0.11.7	"	"	1
$0\frac{5}{3}$	053	"	"	1
$0\frac{1}{1}\frac{7}{0}$	0.17.10	"	"	1
$0\frac{7}{4}$	074	"	"	1
$0\frac{1}{6}^{1}$	0.11.6	"	"	3
$0\frac{1}{8}^{5}$	0.15.8	"	"	1
02	021	"	"	1
$0\frac{1}{5}^{1}$	0.11.5	"	"	1
$0\frac{9}{4}$	094	"	"	1
$0\frac{7}{3}$	073	"	"	1
$0\frac{5}{2}$	052	"	"	1
$0\frac{1}{4}^{1}$	0.11.4	"	"	1
03	031	"	"	1
$0\frac{7}{2}$	072	"	"	1
04	041	"	"	1
$0\frac{9}{2}$	092	"	"	1
05	051	"	"	1
$0\frac{1}{2}^{1}$	0.11.2	"	"	1
06	061	"	"	3
07	071	"	"	3
08	081	"	"	1
09	091	"	"	1
0.11	0.11.1	"	"	3
$\frac{5}{2}0$	502	"	"	1

$\frac{7}{4}0$	704	Binnenthal, Switzerland	1
$\frac{3}{2}0$	302	" "	1
$\frac{5}{4}0$	504	" "	1
$\frac{4}{7}0$	407	" "	2
$\frac{2}{5}0$	205	" "	2
$\frac{1}{3}0$	103	" "	2
$\frac{2}{7}0$	207	" "	2
—10	$\bar{1}01$	" "	1
4	441	" "	2
$\frac{3}{2}$	332	" "	1
$\frac{5}{4}$	554	" "	1
$\frac{2}{3}$	223	" "	2
—1	$\bar{1}11$	" "	1
—2	$\bar{2}21$	" "	1
—3	$\bar{3}31$	" "	3
$1\frac{7}{2}$	272	" "	1
13	131	" "	3
—13	$\bar{1}31$	" "	3
$1\frac{5}{2}$	252	" "	1
12	121	" "	1
$-1\frac{7}{3}$	$\bar{3}73$	" "	3
—12	$\bar{1}21$	" "	3
$1\frac{3}{2}$	232	" "	1
$-1\frac{3}{2}$	$\bar{2}32$	" "	1
$-1\frac{4}{3}$	$\bar{3}43$	" "	1
$1\frac{5}{4}$	454	" "	3
$1\frac{3}{4}$	434	" "	3
$-1\frac{3}{5}$	$\bar{5}35$	" "	3
$1\frac{1}{2}$	212	" "	1
$-1\frac{1}{2}$	$\bar{2}12$	" "	1
$-1\frac{2}{5}$	$\bar{5}25$	" "	3
$-1\frac{1}{3}$	$\bar{3}13$	" "	3
$1\frac{1}{4}$	414	" "	1
$-1\frac{1}{4}$	$\bar{4}14$	" "	1
$-\frac{3}{2}1$	$\bar{3}22$	" "	3
$-\frac{5}{3}1$	$\bar{5}33$	" "	3
$\frac{5}{2}1$	522	" "	1
23	231	" "	1
—23	$\bar{2}31$	" "	1
$2\frac{5}{2}$	452	" "	1

$-2\frac{5}{2}$	$\bar{4}52$	Binnenthal, Switzerland	1
$-2\frac{3}{2}$	$\bar{4}32$	" "	1
$2\frac{4}{3}$	643	" "	3
$-2\frac{1}{2}$	$\bar{4}12$	" "	1
$3\frac{1}{2}$	$\bar{3}21$	" "	3
$\frac{1}{2}\ \frac{1}{4}$	214	" "	3
$\frac{1}{2}2$	142	" "	1
$\frac{5}{2}\ \frac{1}{2}$	512	" "	1
$-\frac{5}{2}2$	$\bar{5}42$	" "	3
$\frac{5}{4}\ \frac{1}{2}$	524	" "	1
$\frac{7}{4}2$	784	" "	1
$\frac{5}{3}3$	593	" "	1
$-\frac{5}{3}\ \frac{4}{3}$	$\bar{5}43$	" "	3

1.—R. H. Solly, 1903, Min. Mag., XIII, p. 151.
2.—H. Baumhauer, 1904, Zeitschr. f. Kryst., XXXIV; 1907, idem., XXXVIII, p. 649.
3.—R. H. Solly, 1912, Min. Mag., XVI, p. 282.

Dumortierite

a: b: c = 0.8897:1:0.6871

a	$\infty 0$	100	San Diego Co., Calif. and New York City	1
b	0∞	010	San Diego Co., Calif.	1
n	2∞	210	" " "	1
g	$\frac{3}{2}\infty$	320	San Diego Co., Calif. and New York City	1
m	∞	110	San Diego Co., Calif. and Clip, Ariz.	1
l	$\infty 2$	120	San Diego Co., Calif. and New York City	1
d	$\frac{1}{2}0$	102	Clip, Ariz.	1
v	$\frac{2}{3}0$	203	San Diego Co., Calif.	1

1.—W. T. Schaller, 1905, U. S. Geol. Surv., Bull. CCLXII, p. 107.

Edingtonite

Orthorhombic Hemimorphic *a: b: c* = 0.9873:1:0.6733

c	0	001	Bôhlet, Sweden	1
m	∞	110	" "	1
p	1	111	" "	1
p_1	-1	$1\bar{1}1$	" "	1
r	12	121	" "	1

r_1	-12	$1\bar{2}1$	Bôhlet, Sweden		1
	$-\frac{3}{2}$	$3\bar{3}2$	"	"	2
	$\frac{1}{9}\ \frac{10}{9}$	1.10.9	"	"	2

1.—O. Nordenskiöld, 1895, Geol. Fören. Förh., VII, p. 597.
2.—H. Sjögren, 1906, Geol. Fören. Förh., XXVIII, p. 169.

Eglestonite

Isometric

a	$\infty 0$	100	Terlingua, Texas		1
d	∞	110	"	"	1
e	$\infty 2$	120	"	"	2
f	$\infty 3$	130	"	"	2
ρ	4	441	"	"	2
p	2	221	"	"	2
r	$\frac{3}{2}$	332	"	"	2
o	1	111	"	"	2
n	$\frac{1}{2}$	112	"	"	1
φ	$\frac{1}{6}$	116	"	"	2
s	$\frac{1}{3}\ \frac{2}{3}$	123	"	"	1
i	$\frac{1}{9}\ \frac{8}{9}$	189	"	"	2
j	$\frac{1}{7}\ \frac{6}{7}$	167	"	"	2
w	$\frac{1}{6}\ \frac{5}{6}$	156	"	"	2
k	$\frac{1}{6}\ \frac{2}{3}$	146	"	"	2
Σ	$\frac{1}{5}\ \frac{4}{5}$	145	"	"	2
F	$\frac{1}{6}\ \frac{1}{3}$	126	"	"	2
v	$\frac{4}{11}\ \frac{7}{11}$	4.7.11	"	"	2
M	$\frac{1}{2}\ \frac{3}{4}$	234	"	"	2
l	$\frac{3}{7}\ \frac{4}{7}$	347	"	"	2

1.—A. J. Moses, 1903, Amer. Journ. Sci., XVI, p. 253.
2.—W. F. Hillebrand and W. T. Schaller, 1909, U. S. Geol. Surv., Bull., CDV, p. 147.

Elpidite

$a:b:c = 0.5117:1:0.9781$

c	0	001	Narsarsuk, Greenland		1
a	$\infty 0$	100	"	"	1
b	0∞	010	"	"	1
u	$\frac{5}{4}\infty$	540?	"	"	1
m	∞	110	"	"	1
t	$\infty\frac{8}{5}$	580	"	"	1

n	$\infty 2$	120	Narsarsuk, Greenland	1
s	$\infty \frac{1}{5}^2$	5.12.0	" "	1
e	$0\frac{1}{3}$	013	" "	1
d	01	011	" "	1
	$\frac{1}{2}0$	102	" "	2

1.—G. Lindström and G. Nordenskiöld, 1894, Geol. Fören. Förh., XVI, pp. 330 343.
2.—G. Flink, 1898, Medd. om Grönland, XIV, p. 230.

Embolite

	31	311	Coahuila, Mexico	1

1.—F. R. Van Horn, 1913, Amer. Journ. Sci., XXXV, p. 23.

Enargite

a: b: c = 0.8665:1:0.8299

y	6∞	610	Famatina, Argentine	2
s	4∞	410	Peru	3
f	$\frac{5}{2}\infty$	520	Willis Gulch, Colo.	2
v	2∞	210	Colorado	1
T	$\frac{4}{3}\infty$	430	Peru	3
i	$\frac{5}{4}\infty$	540	Luzon, Phillipine Isl. and Colo.	2
F	$\frac{9}{8}\infty$	980	Peru	3
N	$\infty\frac{3}{2}$	230	Silverton and Willis Gulch, Colo.	2
h	$\infty 2$	120	Luzon, Phillipine Isl.	4
P	$\infty\frac{5}{2}$	250	Peru	3
l	$\infty 3$	130	Luzon, Phillipine Isl.	4
L	$\infty\frac{7}{2}$	270	Peru	3
R	$\infty 4$	140	"	3
Q	$\infty 5$	150	"	3
D	$\infty 6$	160	"	3
H	06	061	"	3
Θ	05	051	Luzon, Phillipine Isl.	4
G	04	041	Peru	3
π	03	031	Morococha, Peru	2
K	$0\frac{5}{4}$	054	Willis Gulch, Colo.	2
t	$\frac{1}{8}0$	108	Famatina, Argentine	2
A	$\frac{2}{7}0$	207	Famatina, Argent. and Luzon	2
B	$\frac{2}{5}0$	205	Peru	3
w	$\frac{7}{9}0$	709	Parad, Hungary	2
u	30	301	Famatina, Argentine	2

β	60	601	Famatina, Argentine	2
P	$\frac{2}{3}$	223	Luzon, Phillipine Isl.	4
z	$\frac{1}{4}\ \frac{3}{4}$	134	Colorado	1
φ	$\frac{1}{2}\ \frac{3}{2}$	132	Morococha, Peru	2
φ_1	$\frac{3}{4}\ \frac{9}{4}$	394	" "	2
φ_2	13	131	" "	2
φ_3	$\frac{3}{2}\ \frac{9}{2}$	392	" "	2

1.—L. V. Pirsson, 1894, Amer. Journ. Sci., XLVII, p. 212.
*2.—L. J. Spencer, 1897, Min. Mag. XI, pp. 69, 196.
3.—S. Stevanovič, 1903, Zeitschr. f. Kryst., XXXVII, p. 241.
4.—A. J. Moses, 1905, Amer. Journ. Sci., XX, p. 277.

Endeiolite

Isometric

o	1	111	Narsarsuk, Greenland	1

1.—G. Flink, 1901, Medd. om Grönland, XXIV, p. 166.

Epidesmine

$a:b:c = 0.57145:1:0.41810$

c	0	001	Schwarzenberg, Germany	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
p	1	111	" "	1

1.—V. Rosický and S. J. Thugutt, 1913, Abh. bohm. Akad., XVIII, p. 4.

Epididymite

$a:b:c = 0.5758:1:0.5340$

c	0	001	Narsarsuk, Greenland	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
	3∞	310	" "	2
m	∞	110	" "	1
l	$\infty 2$	120	" "	1
n	$\infty 3$	130	" "	1
	$0\frac{1}{3}$	015	" "	3
	$0\frac{5}{8}$	058	" "	3
i	$0\frac{2}{3}$	023	" "	1
h	$0\frac{3}{4}$	034	" "	1
g	01	011	" "	1
e	$0\frac{4}{3}$	043	" "	1

d	02	021	Narsarsuk, Greenland	1
f	04	041	" "	1
λ	06	061	" "	1
χ	08	081	" "	1
	30	301	" "	2
p	2	221	" "	1
	32	321	" "	2

1.—G. Flink, 1893, Geol. Fören. Förh., XV, p. 201.
2.—G. Flink, 1899, Geol. Fören. Förh.
3.—G. Flink, 1898, Bull. Geol. Inst. Upsala, p. 4.

Epidote

	$\infty\frac{5}{3}$	350	Montigliano, Elba, Italy	2
	$0\frac{5}{2}$	052	Sulzbach, Tyrol	5
υ	$0\frac{1}{4}$	014	Unknown locality	4
	39.0	39.0.1	Knappenwand, Tyrol	8
	13.0	13.0.1	Val di Viù, Italy	10
	12.0	12.0.1	" "	10
	10.0	10.0.1	Montigliano, Elba, Italy	2
	80	801	Bettolina, Valloni di Verra, Italy	7
	50	501	" " " "	7
	$\frac{1}{3}\frac{3}{3}0$	13.0.3	Montigliano, Elba, Italy	2
	$\frac{1}{5}\frac{1}{5}0$	11.0.5	Val di Viù, Italy	10
	$\frac{9}{5}0$	905	Montigliano, Elba, Italy	2
	$\frac{1}{1}\frac{9}{1}0$	19.0.11	Nordmark, Sweden	1
	$\frac{2}{1}\frac{5}{2}0$	25.0.12	Chiavrié, Valle di Susa, Italy	9
	$\frac{3}{2}0$	302	Sulzbach, Tyrol	5
	$\frac{1}{1}\frac{9}{4}0$	19.0.14	Montigliano, Elba, Italy	2
	$\frac{2}{2}\frac{7}{0}0$	27.0.20	Nordmark, Sweden	1
	$\frac{5}{4}0$	504	Montigliano, Elba, Italy	2
	$\frac{1}{1}\frac{3}{1}0$	13.0.11	Sulzbach, Tyrol	5
	$\frac{1}{1}\frac{3}{2}0$	13.0.12	Montigliano, Elba, Italy	2
	$\frac{4}{5}\frac{9}{0}0$	49.0.50	Nordmark, Sweden	1
	$\frac{2}{2}\frac{2}{3}0$	22.0.23	Montigliano, Elba, Italy	2
	$\frac{7}{9}0$	709	Nordmark, Sweden	1
	$\frac{2}{3}0$	203	Sulzbach, Tyrol	5
	$\frac{6}{1}\frac{}{1}0$	6.0.11	Nordmark, Sweden	1
	$\frac{2}{5}\frac{3}{0}0$	23.0.50	" "	1
	$\frac{7}{1}\frac{}{7}0$	7.0.17	" "	1
	$\frac{9}{2}\frac{}{2}0$	9.0.22	" "	1

	$\frac{1}{3}\frac{3}{3}0$	13.0.33	Nordmark, Sweden	1
	$\frac{7}{1}\frac{}{8}0$	7.0.18	" "	1
	$\frac{1}{5}\frac{9}{0}0$	19.0.50	Val di Viù, Italy	10
	$\frac{1}{5}\frac{7}{0}0$	17.0.50	Nordmark, Sweden	1
S_0	$\frac{1}{4}0$	104	White Horse Rapids, Yukon, B. C.	12
	$\frac{1}{9}0$	109	Guttannen, Switzerland	8
	$\frac{1}{1}\frac{}{0}0$	1.0.10	Nordmark, Sweden	1
	$\frac{1}{1}\frac{}{1}0$	1.0.11	Notodden, Telemarken, Norway	11
	$-\frac{3}{3}\frac{}{4}0$	$\bar{3}$.0.34	" " "	11
	$-\frac{3}{2}\frac{}{0}0$	$\bar{3}$.0.20	Nordmark, Sweden	1
	$-\frac{3}{1}\frac{}{4}0$	$\bar{3}$.0.14	" "	1
	$-\frac{6}{2}\frac{}{5}0$	$\bar{6}$.0.25	" "	1
	$-\frac{4}{1}\frac{}{5}0$	$\bar{4}$.0.15	Notodden, Telemarken, Norway	11
	$-\frac{8}{2}\frac{}{5}0$	$\bar{8}$.0.25	Nordmark, Sweden	1
	$-\frac{7}{2}\frac{}{0}0$	$\bar{7}$.0.20	" "	1
	$-\frac{1}{5}\frac{9}{0}0$	$\bar{19}$.0.50	" "	1
	$-\frac{9}{2}\frac{}{2}0$	$\bar{9}$.0.22	" "	1
	$-\frac{7}{1}\frac{}{7}0$	$\bar{7}$.0.17	" "	1
	$-\frac{1}{4}\frac{7}{0}0$	$\bar{17}$.0.40	" "	1
	$-\frac{5}{1}\frac{}{1}0$	$\bar{5}$.0.11	" "	1
	$-\frac{2}{5}\frac{3}{0}0$	$\bar{23}$.0.50	" "	1
	$-\frac{8}{1}\frac{}{5}0$	$\bar{8}$.0.15	" "	1
	$-\frac{7}{9}0$	$\bar{7}09$	" "	1
	$-\frac{1}{2}\frac{9}{0}0$	$\bar{19}$.0.20	" "	1
	$-\frac{2}{2}\frac{4}{5}0$	$\bar{24}$.0.25	" "	1
	$-\frac{3}{3}\frac{3}{4}0$	$\bar{33}$.0.34	" "	1
	$-\frac{5}{3}0$	$\bar{5}03$	Val di Viù, Italy	10
	$-\frac{1}{6}\frac{1}{}0$	$\bar{11}$.0.6	" "	10
φ_0	$-\frac{1}{8}\frac{5}{}0$	$\bar{15}$.0.8	White Horse Rapids, Yukon, B. C.	12
	$-\frac{2}{1}\frac{5}{2}0$	$\bar{25}$.0.12	Val di Viù, Italy	10
	$-\frac{7}{3}0$	$\bar{7}03$	" "	10
	$-\frac{5}{2}0$	$\bar{5}02$	" "	10
ψ_0	$-\frac{8}{3}0$	$\bar{8}03$	White Horse Rapids, Yukon, B. C.	12
	$-\frac{1}{2}\frac{1}{}0$	$\bar{11}$.0.2	Nordmark, Sweden	1
	$-\frac{1}{2}\frac{3}{}0$	$\bar{13}$.0.2	" "	1
	—80	$\bar{8}01$	Val di Viù, Italy	10
	—90	$\bar{9}01$	" "	10
	—11.0	$\bar{11}$.0.1	" "	10
	—14.0	$\bar{14}$.0.1	Ala-Thal, Tyrol	8
m	$\frac{1}{7}$	117	Val di Viù, Italy	10

δ	$\frac{1}{8}$	118	Val di Viù, Italy	10
n	$\frac{1}{9}$	119	" "	10
	$\frac{1}{1\,9}$	1.1.19	" "	10
	$\frac{1}{2\,5}$	1.1.25	" "	10
	14	14.14.1	Monte Acuto, Vico Canavese, Italy	8
	$-\frac{9}{4}$	$\bar{9}94$	Montigliano, Elba, Italy	2
	$-\frac{5}{2}$	$\bar{5}52$	" " "	2
	-3	$\bar{3}31$	" " "	2
	$-1\frac{6}{7}$	$\bar{7}67$	" " "	2
	$-1\frac{5}{4}$	$\bar{4}54$	Morkhult, Norway	1
	$-1\frac{5}{8}$	$\bar{8}.15.8$	Montigliano, Elba, Italy	2
	$-1\frac{7}{3}$	$\bar{3}.17.3$	" " "	2
	-1.10	$\bar{1}.10.1$	" " "	2
	-1.13	$\bar{1}.13.1$	" " "	2
	$\frac{9}{1\,4}1$	9.14.14	" " "	2
	$\frac{1\,1}{2\,0}1$	11.20.20	" " "	2
	$-\frac{1\,5}{1\,6}1$	$\bar{15}.16.16$	" " "	2
o	$-\frac{5}{4}1$	$\bar{5}44$	Sulzer, Prince of Wales Island, Alaska	6
j	$-\frac{7}{5}1$	$\bar{7}55$	Sulzer, Prince of Wales Island, Alaska	6
x	$-\frac{3}{2}1$	$\bar{3}22$	Montigliano, Elba, Italy	2
	$-\frac{2\,1}{1\,0}1$	$\bar{21}.10.10$	" " "	2
	$-\frac{1\,3}{6}1$	$\bar{13}.6.6$	Sulzbach, Tyrol	5
	$-\frac{8}{3}1$	$\bar{8}33$	Montigliano, Elba, Italy	2
	-51	$\bar{5}11$	Habachthal, Tyrol	3
	-71	$\bar{7}11$	" "	3
	-81	$\bar{8}11$	" "	3
Y	$\frac{1}{2}\,\frac{1}{4}$	214	Val di Viù, Italy	10
	$-\frac{1}{4}\,\frac{3}{4}$	$\bar{1}34$	Ala, Piedmont, Italy?	13
	-42	$\bar{4}21$	Nordmark, Sweden	1
	$-2\frac{1}{3}$	$\bar{6}13$	" "	1
	$-\frac{1\,1}{5}\,\frac{6}{5}$	$\bar{11}.6.5$	Sulzbach, Tyrol	5
	$-2\frac{1}{1\,2}$	$\bar{24}.1.12$	Nordmark, Sweden	1
	$-\frac{2\,3}{7}\,\frac{1\,0}{7}$	$\bar{23}.10.7$	Montigliano, Elba, Italy	2
	$-\frac{2\,8}{9}\,\frac{4}{3}$	$\bar{28}.12.9$	" " "	2
	$-\frac{1\,3}{4}\,\frac{1\,1}{8}$	$\bar{26}.11.8$	" " "	2

1.—G. Flink, 1886, Bihang. t. k. Sven. Vet. Ak. Stockholm, XII, p. 2.
2.—E. Artini, 1887, Rend. Accad. Linc., IV, p. 380.
3.—J. Gränzer, 1887, Min. u. Petro. Mitth., IX, p. 36.

4.—L. Brugnatelli, 1890, Zeitschr. f. Kryst., XVII, p. 529.
5.—F. Zambonini, 1900, Neues Jahrb. f. Min., I, p. 181.
6.—C. Palache, 1902, Proc. Amer. Acad. Sci., XXXVII, p. 531.
7.—F. Zambonini, 1903, Rend. Accad. Linc., XII, p. 567.
*8.—F. Zambonini, 1903, Zeitschr. f. Kryst., XXXVII, p. 1.
9.—F. Zambonini, 1906, Rend. Accad. Linc., XV, (2), p. 179.
10.—Z. Toborffy, 1907, Zeitschr. f. Kryst., XLIII, p. 564.
11.—O. Andersen, 1911, Archiv f. Math. og Naturv., XXXI, p. 48.
12.—E. Poitevin, 1919, Amer. Miner., IV, p. 24.
13.—L. J. Spencer, 1920, Min. Mag., XIX, No. 88, p. 7.

Epistolite

$a:b:c = 0.803:1:1.206 \quad \beta = 74° 42'$

c	0	001	Julianehaab, Greenland		1
m	∞	110	"	"	1
o	01	011	"	"	1
r	$\frac{5}{4}0$	504	"	"	1
s	$-\frac{1}{2}0$	$\bar{1}02$	"	"	1

1.—O. B. Böggild, 1900, Medd. om Grönland, XXIV, p. 183.

Erikite

$a:b:c = 0.57552:1:0.75796$

o	0	001	Tunugdliarfik-Fjord, Greenland		1
a	∞0	100	"	"	1
b	0∞	010	"	"	1
m	∞	110	"	"	1
n	∞2	120	"	"	1
o	∞3	130	"	"	1
p	$\infty\frac{7}{2}$	270	"	"	1
e	01	011	"	"	1
f	$0\frac{3}{2}$	032	"	"	1
g	02	021	"	"	1
h	$0\frac{5}{2}$	052	"	"	1
i	03	031	"	"	1
s	20	201	"	"	1
r	10	101	"	"	1
t	1	111	"	"	1
u	$\frac{1}{4}$	114	"	"	1

1.—O. B. Böggild, 1903, Medd. om Grönland, XXVI, p. 93.

Erythite

	$\infty\frac{5}{3}$	350	Cobalt, Ontario, Can.	1
	$\frac{1}{4}0$	104	" " "	1

1.—W. F. Green, 1910, Trans. Can. Inst., VIII, p. 443.

Euchroite

d	10	101		1
f	$\frac{1}{2}0$	102		1

1.—Gissinger, 1892, Zeitschr. f. Kryst., pp. 22, 367.

Euclase

	$\infty\frac{7}{4}$	470	Brazil	1
s	$\frac{3}{2}\,\frac{1}{4}^{7}$	6.17.4	Locality unknown	2
	$\frac{1}{7}^{2}3$	12.21.7	Brazil	1

1.—V. Dürrfeld, 1910, Zeitschr. f. Kryst., XLVII, p. 376.
2.—R. Köchlin, 1912, Min. u. petro. Mitth., XXXI, p. 532.

Eudidymite

	$0\frac{5}{3}$	053	Narsarsuk, Greenland	1
	2	221	" "	2
	$-\frac{1}{4}$	$\bar{1}14$	" "	2
	$-\frac{3}{8}$	$\bar{3}38$	" "	2
	$-\frac{5}{9}$	$\bar{5}59$	" "	2
	$\frac{6}{5}\,\frac{2}{5}$	625	" "	1
	$5\frac{5}{3}$	15.5.3	" "	1
	$-5\frac{5}{3}$	$\bar{1}5.5.3$	" "	1

1.—G. Flink, 1898, Medd. om. Grönland, XIV, p. 230.
2.—G. Flink, 1898, Bull. Geol. Inst. Upsala, IV.

Ferberite

$a:b:c = 0.8255:1:0.8664 \quad \beta = 89°\ 32'$

L	7∞	710	Boulder Co., Colo.	4
	6∞	610	Greenland	3
N	$\frac{1}{2}^{1}\infty$	$\bar{1}1.2.0$	Boulder Co., Colo.	4
M	5∞	510	" "	4
G	$\frac{7}{2}\infty$	720	" "	4
F	$\frac{5}{2}\infty$	520	" "	4
C	$\frac{9}{4}\infty$	940	" "	4
R	$\frac{1}{7}^{5}\infty$	15.7.0	" "	4
i	$\infty\,\frac{1}{7}^{1}$	7.11.0	South Dakota	1

H	$\frac{9}{4}0$	904	Boulder Co., Colo.	4
A	$\frac{3}{7}$	337	" "	4
D	$1\frac{1}{3}$	313	" "	4
B	$\frac{1}{3}\ \frac{2}{3}$	123	" "	4
p	$2\frac{1}{4}$	214	" "	2
E	$\frac{5}{14}\ \frac{9}{14}$	5.9.14	" "	4

1.—C. H. Warren, 1901, Amer. Journ. Sci., XI, p. 372.
2.—A. J. Moses, 1905, Amer. Journ. Sci., XX, p. 281.
3.—O. B. Böggild, 1905, Min. om Grönland, p. 180.
*4.—W. T. Schaller, 1914, U. S. Geol. Surv., Bull. DLXXXIII, p. 40.

Fichtelite

$a:b:c = 1.4249:1:1.7165 \quad \beta = 52°\ 56'$

z	01	011	Borkovic, Bohemia	2
e	—20	$\bar{2}01$	" "	2
x	$-\frac{3}{4}0$	$\bar{3}04$	" "	2
	$-\frac{1}{3}0$	$\bar{1}03$	Kolbermoor, Bavaria, Ger.	3
o	—1	$\bar{1}11$	Salzendeich, Austria	1
y	$-\frac{1}{4}$	$\bar{1}14$	Borkovic, Bohemia	2

1.—H. Böckh, 1904, Földt. Közlöny, XXXIV, p. 335.
2.—F. Pazák and V. Rosicky, 1908, Zeitschr. f. Kryst., XLIV, p. 332.
3.—A. Rosati, 1910, Rend. Accad. Linc., XIX, p. 450.

Florencite

Hexagonal Rhombohedral $a\ c = 1:1.15875$

c	0	0001	Minas Geraes, Brazil	1
m	$\infty 0$	$10\bar{1}0$	" " "	1
r	10	$10\bar{1}1$	" " "	1
f	—20	$02\bar{2}1$	" " "	1

1.—E. Hussak and G. T. Prior, 1900, Min. Mag., XII, p. 244.

Fluorite

g	9∞	910	Nordmark, Sweden	6
L	$\frac{8}{7}\infty$	870	Christiania, Norway	8
Θ	19.1	19.1.1	Rossie, N. Y.	5
	17.1	17.1.1	Epprechtstein, Fichtelberg, Sax.	2
	10.1	10.1.1	" " "	2
σ	91	911	Nordmark, Sweden	6
M	$\frac{4}{3}1$	433	Christiania, Norway	8
	$\frac{8}{7}1$	877	Epprechtstein, Fichtelberg, Sax.	2

	53	531	Belgium	1
	$\frac{5}{3}$ $\frac{4}{3}$	543	"	1
	93	931	Epprechtstein, Fichtelberg, Sax.	2
H	$\frac{9}{2}$ $\frac{5}{2}$	952	Christiania, Norway and Quincy, Mass.	7+8
K	$\frac{11}{2}$ $\frac{7}{2}$	11.7.2	Christiania, Norway	8
	$\frac{16}{3}$ $\frac{10}{3}$	16.10.3	Quincy, Mass.	7
	$\frac{19}{5}$ $\frac{9}{5}$	19.9.5	Epprechtstein, Fichtelberg, Sax.	2
	$\frac{20}{3}$ $\frac{4}{3}$	20.4.3	Pisek, Bohemia	4
j	$\frac{15}{4}$ $\frac{7}{4}$	15.7.4	Budapest, Hungary	3
r	$\frac{24}{7}$ $\frac{10}{7}$	24.10.7	" "	3
	$\frac{7}{5}$	775?	Christiania, Norway	8

1.—H. Buttgenbach, 1899, Ann. Soc. Géol. Belg., XXVII, p. 111.
2.—M. Weber, 1903, Zeitschr. f. Kryst., XXXVII, p. 433.
3.—V. Hulyak, 1903, Földt. Közlöny, XXXIII, p. 54.
4.—A. Krejči, 1905, Abh. d. böhm. Akad., No. 2, p. 3.
5.—H. P. Whitlock, 1910, N. Y. State Mus., Bull. CXL, p. 198.
6.—G. Flink, 1910, Ark. Min. o. Geol., III, p. 1.
7.—C. Palache and C. H. Merwin, 1911, Amer. Journ. Sci., XXXI, p. 556.
8.—V. M. Goldschmidt, 1911, Videnskapsselskapet Skrifter, I, p. 233.

Franklinite

e	5∞	510	Franklin Furnace, N. J.	1

1.—A. H. Phillips, 1917, Amer. Miner., II, p. 5.

Fremontite

$a:b:c = 0.7633:1:0.7633 \quad \alpha = 108° 31' \quad \beta = 97° 48' \quad \gamma = 106° 27'$

c	0	001	Fremont Co., Colo.	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
z	$\infty 2$	120	" "	1
e	02	021	" "	1
h	10	101	" "	1

1.—W. T. Schaller, 1916, U. S. Geol. Surv., Bull. DCX, p. 143.

Freidlerite

	$\infty 5$	150	Laurium, Greece	1

1.—A. Lacroix and A. de Schulten, 1908, Bull. Soc. fr. Min., XXXI, p. 83.

Galena

p	$\frac{1}{13}$	1.1.13	Unknown locality	3
g	$\frac{1}{8}$	118	Weiden, Fischbachthal, Tyrol	5

	$\frac{4}{7}$	447	Freiberg, Germany	2
π	$\frac{2}{7}1$	277	Weiden, Fischbachthal, Tyrol	5
	$\frac{1}{5}1$	155	Neudorf, Germany	1
	$\frac{1}{6}1$	166	Traversella, Italy	4
a	$\frac{1}{5}\ \frac{3}{10}$	2.3.10	Weiden, Fischbachthal, Tyrol	5
e	$\frac{1}{10}\ \frac{3}{20}$	2.3.20	" " "	5

1.—G. Cesàro, 1892, Zeitschr. f. Kryst., XX, p. 468.
2.—G. Cesàro, 1898, Ann. Soc. Géol. belg., XXIV.
3.—A. F. Rogers, 1901, Amer. Journ. Sci., XII, p. 45.
4.—L. Colomba, 1905, Rend. Accad. Linc., XV, p. 636.
5.—V. Dürrfeld, 1910, Zeitschr. f. Kryst., XLVII, p. 375.

Garnet

E	$\frac{3}{8}\ \frac{5}{8}$	358	Rothenkopf, Tyrol	1
D	$\frac{3}{10}\ \frac{7}{10}$	3.7.10	" "	1
	$\frac{2}{5}\ \frac{3}{5}$	235	Biella, Italy	3
	$\frac{4}{9}\ \frac{5}{9}$	459	Brompton Lake, Quebec, Can.	2

1.—A. Catherine, 1888, Min. u. petro. Mitth., X, p. 55.
2.—C. Palache and H. O. Wood, 1904, Amer. Journ. Sci., XVIII, p. 344.
3.—F. Zambonini, 1904, Zeitschr. f. Kryst., XL, p. 225.

Geikielite

Hexagonal $a:c=1:1.370$

c	0	0001	Ceylon	1
φ	$\frac{5}{8}0$	$50\bar{5}8$	"	1

1.—P. P. Sustschinsky, 1902, Zeitschr. f. Kryst., XXXVII, p. 57.

Geocronite

$a:b:c=0.6145:1:0.6797$

c	0	001	Val Castello, Tuscany, Italy	1
m	∞	110	" " "	1
	$0\frac{5}{8}$	058	" " "	1
	$0\frac{6}{7}$	067	" " "	1
	01	011	" " "	1
	$0\frac{3}{2}$	032	" " "	1
	02	021	" " "	1
	$\frac{2}{5}$	225	" " "	1
	1	111	" " "	1

1.—G. d'Achiardi, 1901, Alt. Soc. Tosc. Mem., XVIII.

Georgiadesite

a: b: c = 0.5770:1:0.2228

$\infty 0$	100	Laurium, Greece		1
0∞	010	"	"	1
01	011	"	"	1
$0\frac{1}{4}$	0.11.4	"	"	1
45	451	"	"	1
$4\frac{5}{4}$	16.5.4	"	"	1
$2\frac{5}{2}$	4.15.2	"	"	1

1.—A. Lacroix and A. de Schulten, 1907, Compt. Rend., CXLV, p. 783.

Gismondite

l	$0\frac{1}{3}$	013	Podhorn, Marienbad, Bohemia	1

1.—A. Himmelbauer, 1912, Min. u. petro. Mitth., XXXI, p. 42.

Glaucochroite

a: b: c = 0.4409:1:0.5808

a	$\infty 0$	100	Franklin Furnace, N. J.		1
b	0∞	010	"	"	" 1
m	∞	110	"	"	" 1
s	$\infty 2$	120	"	"	" 1
x	$\frac{1}{3}0$	103	"	"	" 1
h	02	021	"	"	" 1
e	1	111	"	"	" 1
f	12	121	"	"	" 1

1.—C. Palache, 1910, Amer. Journ. Sci., XXIX, p. 181.

Goethite

x	$\frac{4}{3}\infty$	430	Lostwithiel, Cornwall, Eng.	2
n	$\infty 3$	130	Přibram, Bohemia	1
e	01	011	" "	1
w	$\frac{4}{3}\frac{1}{3}$	413	Lostwhithiel, Cornwall, Eng.	2
t	$\frac{4}{3}\frac{8}{2\,7}$	36.8.27	Vasko, Krassó-Szörény, Hungary	3

1.—V. Rosicky, 1908, Abh. d. böhm. Akad., XIII.
2.—V. Goldschmidt and A. L. Parsons, 1910, Zeitschr. f. Kryst., XLVII, p. 240.
3.—M. Löw, 1911, Földt. Közlöny, XLI, p. 811.

Gold

$\frac{1}{8}$	118	Ural Mountains, Russia	1

1.—P. Jeremejeff, 1895, Verh. russ. Min. Ges., XXXIII.

Graftonite

$a:b:c = 0.886:1:0.582 \quad \beta = 66°$

a	$\infty 0$	100	Grafton, N. H.	1
b	0∞	010	" "	1
m	∞	110	" "	1
l	$\infty 2$	120	" "	1
n	$\infty 3$	130	" "	1
d	01	011	" "	1
e	02	021	" "	1
p	1	111	" "	1

1.—S. L. Penfield, 1900, Amer. Journ. Sci., IX, p. 20.

Grothine

$a:b:c = 0.4575:1:0.8484$

c	0	001	Campagna, Italy	1
b	0∞	010	" "	1
m	∞	110	" "	1
e	10	101	" "	1
o	1	111	" "	1
r	12	121	" "	1

1.—F. Zambonini, 1913, Rend. Accad. Linc., (5) XXII, p. 801.

Gypsum

p	5∞	510	Andreasberg, Harz, Germany	1
	$\frac{1}{7}^{3} \infty$	13.7.0	Bad Lands, S. Dakota	3
φ	$\infty \frac{5}{3}$	350	Andreasberg, Harz, Germany	1
	$-\frac{2}{3}0$	$\bar{2}03$	Paris, France	2
μ	$\frac{5}{3}$	553	Artificial	6
π	$\frac{1}{3}$	113	"	6
	—21	$\bar{2}11$	Paris, France	2
o	$-1\frac{1}{2}$	$\bar{2}12$	Ballabio, Italy	4
p	$-1\frac{1}{3}$	$\bar{3}13$	" "	4
	$-\frac{3}{4} \frac{1}{4}$	$\bar{3}14$	Bellisio,	5
	$-\frac{5}{9} \frac{4}{9}$	$\bar{5}49$	Paris, France	2
	$\frac{1}{2}\frac{5}{6} \frac{2}{2}\frac{1}{6}$	15.21.26	" "	2

1.—O. Luedecke, 1896, Min. d. Harzes, p. 377.
2.—A. Lacroix, 1898, Bull. Soc. fr. Min., XXI, p. 39.
3.—A. F. Rogers, 1902, School of Mines Quar., XXIII, p. 133.
4.—E. Artini, 1900, Rend. Inst. Lomb., XXXIII, p. 1181.
5.—G. Cesàro, 1905, Bull. Ac. Belg., p. 140.
6.—C. Perrier, 1905, Rend. Accad. Linc., (5) XXIV, p. 159.

Gyrolite

Hexagonal Rhombohedral $a:c=1:1.9360$

c	0	0001	Niakornat, Greenland	1
r	10	$10\bar{1}1$	" "	1
u	$\frac{1}{2}0$	$10\bar{1}2$	" "	1

1.—O. B. Böggild, 1908, Medd. om. Grönland, XXXIV, p. 93.

Hackmanite

Isometric

d	∞	110	Kola, Lapland	1

1.—L. H. Borgstrom, 1901, Geol. Fören. Förh., XXIII, p. 563.

Hamlinite

Hexagonal Rhombohedral

r	10	$10\bar{1}1$	Oxford Co., Maine	1
f	02	$02\bar{2}1$	" "	1

1.—S. L. Penfield, 1897, Amer. Journ. Sci., IV, p. 313.

Hambergite

$a:b:c=0.8023:1:0.7268$

c	0	001	Madagascar	1
l	4∞	410	"	1
h^7	$\frac{4}{3}\infty$	430	Antsirabe, France	2
h''	$\frac{6}{5}\infty$	650	" "	2
k'	$\infty\frac{3}{2}$	230	Madagascar	1
d	$\frac{1}{4}0$	104	"	1
r	$\frac{1}{2}$	112	"	1
p	1	111	"	1
v	2	221?	"	1
s	$1\frac{1}{2}$	212	"	1
u	12	121	"	1
y	$\frac{1}{2}1$	122	"	1
w	$\frac{1}{2}\frac{3}{2}$	132	"	1
q	$\frac{1}{3}\frac{2}{3}$	123	"	1
t	$\frac{1}{4}\frac{1}{2}$	124	"	1

1.—V. Goldschmidt and F. C. Müller, 1910, Zeitschr. f. Kryst., XLVIII, p. 473.
2.—H. Ungemach, 1912, Bull. Soc. fr. Min., XXXV.

Hancockite

c	0	001	Franklin Furance, N. J.			1
a	∞0	100	"	"	"	1
e	10	101	"	"	"	1
r	—10	$\bar{1}01$	"	"	"	1
n	1	111	"	"	"	1

1.—S. L. Penfield and C. H. Warren, 1899, Amer. Journ. Sci., VIII, p. 339.

Hatchite

a: b: c = 0.9787:1:1.1575 $\alpha = 116° 53\frac{1}{2}'$ $\beta = 85° 12'$ $\gamma = 113° 44\frac{1}{2}'$

c	0	001	Binnenthal, Switzerland		1
a	∞0	100	"	"	1
b	0∞	010	"	"	1
n	2∞	210	"	"	1
l	$-\frac{3}{2}\infty$	$\bar{3}20$	"	"	1
m	∞	110	"	"	1
M	—∞	$\bar{1}10$	"	"	1
g	$-0\frac{1}{2}$	$0\bar{1}2$	"	"	1
e	—01	$0\bar{1}1$	"	"	1
f	—20	$0\bar{2}1$	"	"	1
d	$\frac{1}{3}0$	103	"	"	1
r	—1	$1\bar{1}1$	"	"	1
o	—1	$11\bar{1}$	"	"	1
p	—1	$\bar{1}11$	"	"	1
w	—2	$2\bar{2}1$	"	"	1
s	$-\frac{1}{2}$	$\bar{1}12$	"	"	1
v	—12	$12\bar{1}$	"	"	1
i	—25	$2\bar{5}1$	"	"	1
q	$-\frac{1}{3}\frac{5}{6}$	$25\bar{6}$	"	"	1
j	$-\frac{1}{6}\frac{1}{2}$	$13\bar{6}$	"	"	1
w	—32	$32\bar{1}$	"	"	1

1.—R. H. Solly and G. F. Herbert-Smith, 1912, Min. Mag., XVI, p. 287.

Hauchecornite

Tetragonal *a: c* = 1:1.05215

c	0	001	Hamm, Siegen, Ger.			1
a	∞0	100	"	"	"	1
m	∞	110	"	"	"	1
e	10	101	"	"	"	1

s	$\frac{1}{2}$	112	Hamm, Siegen, Ger.	1
p	1	111	" " "	1

1.—R. Scheibe, 1888, Zeitschr. Geol. Ges., XL, p. 611.

Hauerite

β	$\frac{4}{7}1$	477	Raddusa, Hungary	1

1.—V. Goldschmidt and R. Schroeder, 1908, Zeitschr. f. Kryst., XLV, p. 214.

Hausmannite

a: c = 1:1.1661

a	$\infty 0$	100	Brazil	1
i	$\frac{1}{9}$	119	"	1
	$\frac{5}{11}$	5.5.11	Långban, Sweden	2
	$\frac{3}{5}$	335	" "	2
	$\frac{2}{3}$	223	" "	2
	$1\frac{1}{4}$	414	" "	2
k	13	131	Brazil	1
h	$\frac{1}{3}\ \frac{2}{3}$	123	"	1
x	$\frac{5}{9}\ \frac{7}{9}$	579	"	1

1.—R. Köchlin, 1908, Min. u. petro. Mitth., XXVII, p. 259.
2.—G. Flink, 1910, Ark. Kemi. Min. Geol., III.

Hautefeullite

Monoclinic?

a	$\infty 0$	100	Bamle, Norway	1
b	0∞	010	" "	1
m	∞	110	" "	1

1.—L. Michel, 1893, Bull. Soc. fr. Min., XVI, p. 38.

Hellandite

a: b: c = 2.0646:1:2.1570 $\beta = 109° 45'$

c	0	001	Kragerö, Norway	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
n	$\frac{3}{2}\infty$	320	" "	1
g	$\frac{5}{4}\infty$	540	" "	1
m	∞	110	" "	1
t	$\infty 2$	120	" "	1
o	01	011	" "	1

g	30	301	Kragerö, Norway		1
t	$\frac{2}{5}0$	205	"	"	1
r	$-\frac{1}{3}0$	$\bar{1}03$	"	"	1
d	$-\frac{1}{2}0$	$\bar{1}02$	"	"	1
x	—10	$\bar{1}01$	"	"	1
e	—20	$\bar{2}01$	"	"	1
p	$-\frac{1}{2}1$	$\bar{1}22$	"	"	1

1.—W. C. Brögger. Nyt. Mag. f. Naturv.

Hematite

	$\infty 7$	$17\bar{8}0$	Caveradi, Grisons, Switzerland		7
J	$\frac{5}{7\,2}$	$5.5.\bar{1}0.72$	Vesuvius, Italy		8
U	$\frac{1\,6}{3}$	$16.16.\bar{3}2.3$	Lower California, Mexico		5
z'	$\frac{2\,0}{9}0$	$20.0.\bar{2}0.9$	Gellivare, Sweden		6
x'	$\frac{2\,7}{1\,7}0$	$27.0.\bar{2}7.17$	"	"	6
Λ	$\frac{4}{9}0$	$40\bar{4}9$	Dognácska, Hungary		4
	$\frac{1}{5}0$	$10\bar{1}5$	Montdore, Haute-Saône, France		1
	$0\frac{1}{1\,2}$	$0.1.\bar{1}.12$	Guanajuato Mexico		5
ω	$\frac{1}{1\,1}\,\frac{5}{1\,1}$	$1.5.\bar{6}.11$	Dognácska, Hungary		4
Φ	$\frac{1}{7}\,\frac{3}{7}$	$13\bar{4}7$	"	"	4
c	$\frac{5}{2\,3}\,\frac{9}{2\,3}$	$5.9.\bar{1}4.23$	"	"	4
o	$\frac{3}{1\,3}\,\frac{5}{1\,3}$	$3.5.\bar{8}.13$	"	"	4
R	$\frac{1}{4}\,\frac{3}{8}$	$23\bar{5}8$	"	"	4
Y	$\frac{5}{1\,9}\,\frac{7}{1\,9}$	$5.7.\bar{1}2.19$	"	"	4
L	$\frac{3}{1\,1}\,\frac{4}{1\,1}$	$3.4.\bar{7}.11$	"	"	4
S	$\frac{1\,1}{2\,5}\,\frac{7}{2\,5}$	$11.7.\bar{1}8.25$	Vesuvius, Italy		8
U	$\frac{7}{1\,2}\,\frac{5}{2\,4}$	$14.5.\bar{1}9.24$	"	"	8
	$\frac{2}{3}\,\frac{1}{3}$	$21\bar{3}3$	Binnenthal, Switzerland		3
	$\frac{4}{5}\,\frac{2}{5}$	$42\bar{6}5$	Montdore, Haute-Saône, France		1
	$\frac{5}{6}\,\frac{5}{1\,2}$	$10.5.\bar{1}5.12$	Binnenthal, Switzerland		3
s	$\frac{6}{7}\,\frac{2}{7}$	$62\bar{8}7$	Pajsberg, Wermland, Sweden		6
j	43	$43\bar{7}1$	Kakuk Mountains, Hungary		9
	$\frac{1\,4}{5}\,\frac{6}{5}$	$14.6.\bar{2}0.5$	Norberg, Sweden		6
	$\frac{9}{2}\,\frac{1}{2}$	$9.1.\bar{1}0.2$	Caveradi, Grisons, Switzerland		7
Ω	10.2	$10.2.\bar{1}2.1$	Dognácska, Hungary		4
	$\frac{2\,5}{4\,7}\,\frac{2\,4}{4\,7}$	$25.24.\bar{4}9.47$	Montdore, Haute-Saône, France		1
	$\frac{1\,3}{1\,9}\,\frac{1\,2}{1\,9}$	$13.12.\bar{2}5.19$	"	"	1
	$\frac{2\,7}{3\,9}\,\frac{2\,4}{3\,9}$	$27.24.\bar{5}1.39$	"	"	1
	$\frac{1\,7}{2\,2}\,\frac{5}{1\,1}$	$17.10.\bar{2}7.22$	"	"	1
	$\frac{1\,5}{1\,9}\,\frac{8}{1\,9}$	$15.8.\bar{2}3.19$	"	"	1

	$\frac{1}{12}\frac{1}{6}$	11.2.$\bar{13}$.12	Madagascar	10
f'	16	16$\bar{7}$1	Norberg, Sweden	6
U	$\frac{1}{5}$1	15$\bar{6}$5	Pajsberg, Sweden	6
ψ	$\frac{1}{8}\frac{5}{8}$	15$\bar{6}$8	Dognácska, Hungary	4
j	$\frac{2}{5}\frac{8}{5}$	2.8.$\bar{10}$.5	" "	4
T	$\frac{2}{5}\frac{6}{5}$	26$\bar{8}$5	Pajsberg, Wermland, Sweden	6
Ξ	$\frac{1}{4}\frac{3}{4}$	13$\bar{4}$4	Minas Geraes, Brazil	2
	$\frac{2}{5}\frac{4}{5}$	24$\bar{6}$5	Binnenthal, Switzerland	3
	$\frac{3}{8}\frac{5}{4}$	3.10.$\bar{13}$.8	Montdore, Haute-Saône, France	1
	$\frac{3}{5}\frac{5}{9}\frac{4}{5}\frac{8}{9}$	35.48.$\bar{83}$.59	" " "	1
	$\frac{8}{15}\frac{11}{15}$	8.11.$\bar{19}$.15	Minas Geraes, Brazil	2
	$\frac{4}{9}\frac{7}{9}$	4.7.$\bar{11}$.9	" " "	2

1.—F. Gonnard, 1898, Compt. rend., CXXVI, p. 1048.
2.—Dufet, 1903, Bull. Soc. fr. Min., XXVI, p. 60.
3.—R. W. Harre, 1906, Zeitschr. f. Kryst., XLII, p. 280.
4.—E. Kleinfeldt, 1907, Neues Jahrb. f. Min., B.-B., XXIV, p. 325.
5.—H. Ungemach, 1910, Bull. Soc. fr. Min., XXXIII, p. 375.
6.—G. Flink, 1910, Ark. Min. o. Geol., III, p. 1.
7.—H. Ungemach, 1912, Ann. Soc. Géol. Belg., Mém., XXXIX, p. 5.
8.—L. Cuccia, 1913, Rend. Accad. Linc., (5) XXII, p. 587.
9.—K. Zimanyi, 1913, Földt. Közlöny, XLIII, p. 511.
10.—H. Ungemach, 1916, Bull. Soc. fr. Min., XXXIX.

Herderite

$a:b:c = 0.63075:1:0.42742 \quad \beta = 89° 54'$

c	0	001	Paris, Maine	1
a	∞0	100	" "	1
b	0∞	010	" "	1
m	∞	110	" "	1
l_1	$\infty\frac{3}{2}\frac{7}{0}$	20.37.0	Epprechtstein, Bavaria, Ger.	3
l	∞2	120	Paris, Maine	1
μ	∞3	130	" "	1
u	01	011	Stoneham, Maine	1
t	0$\frac{3}{2}$	032	Paris, Maine	1
v	03	031	" "	1
S	06	061	" "	1
E	80	801	Epprechtstein, Bavaria, Ger.	2
ϵ	—80	$\bar{8}$01	" " "	
$\mathfrak{d}$	—30	$\bar{3}$01	Auburn, Maine	1
e	$\frac{3}{2}$0	302	Stoneham, Maine	1
$\mathfrak{e}$	—$\frac{3}{2}$0	$\bar{3}$02	" "	1
d	10	101	" "	1

δ	—10	$\bar{1}01$	Epprechtstein, Bavaria, Ger.	2
f	—$\frac{2}{3}$0	$\bar{2}03$	" " "	3
r	$\frac{1}{2}$	112	Auburn, Maine	1
p	1	111	Stoneham, Maine	1
π	—1	$\bar{1}11$	Epprechtstein, Bavaria, Ger.	3
y	$\frac{3}{4}$	334	" " "	3
$\mathfrak{g}$	—$\frac{3}{4}$	$\bar{3}34$	" " "	3
q	$\frac{3}{2}$	332	Stoneham, Maine	1
$\mathfrak{q}$	—$\frac{3}{2}$	$\bar{3}32$	" "	1
n	3	331	" "	1
$\mathfrak{n}$	—3	$\bar{3}31$	" "	1
o	4	441	" "	1
p_{24}	—24	$\overline{24}.24.1$	Epprechtstein, Bavaria, Ger.	3
r	—12	$\bar{1}21$	Greenwood, Maine	1
g	—1$\frac{4}{3}$	$\bar{3}43$	Auburn, "	4
k	$\frac{1}{2}$1	122	Paris, "	1
w	$\frac{3}{4}$3	3.12.4	" "	1
h	$\frac{3}{5}$ $\frac{9}{5}$	395	Epprechtstein, Bavaria, Ger.	3
z	—$\frac{3}{4}$ $\frac{9}{4}$	$\bar{3}94$	Greenwood, Maine	1
$\mathfrak{p}$	39	391	" "	1
x	$\frac{3}{2}$3	362	" "	1
$\mathfrak{i}$	24	241	Epprechtstein, Bavaria, Ger.	3
h	—63	$\bar{6}31$	Auburn, Maine	4

1.—S. L. Penfield, 1894, Amer. Journ. Sci., XLVII, p. 329.
2.—V. Dürrfeld, 1909, Zeitschr. f. Kryst., XLVII, pp. 242, 248.
3.—V. Dürrfeld, 1910, Zeitschr. f. Kryst., XLVIII, p. 236.
4.—W. E. Ford, 1911, Amer. Journ. Sci., XXXII, p. 283.

Hessite

s	$\frac{5}{2}$	552	Botés, Siebenburgen, Hungary	1
r	4	441	" " "	1

1.—V. Rosický, 1908, Abh. d. böhm. Akad., XIII, No. 28.

Heulandite

w	0$\frac{3}{2}$	032	Scotland	1
	50	501	East Greenland	2
n	1	111	Scotland	1

1.—J. G. Goodchild, 1903, Trans. Geol. Soc., Glasgow, XII.
2.—O. B. Böggild, 1905, Medd. om Grönland, XXVIII, p. 120.

Hibbenite

a: b: c = 0.589:1:0.488

a	∞0	100	Salmo, B. C.	1
b	0∞	010	" "	1
s	∞2	120	" "	1
d	10	101	" "	1
p	1	111	" "	1

1.—A. H. Phillips, 1916, Amer. Journ. Sci., XLII, p. 275.

Hibschite

Isometric

d	10	101	Marienberg, Bohemia	1
o	1	111	" "	1

1.—F. Cornu, 1905, Min. Mitth., XXIV, p. 327; 1906, idem, XXV, p. 249.

Hinsdalite

Hexagonal Rhombohedral *a: c* = 1:1.2677

c	0	0001	Lake City, Hinsdale Co., Calif.	1
r	10	$10\bar{1}1$	" " " " "	1
	—10	$01\bar{1}1$	" " " " "	1

1.—E. S. Larsen and W. T. Schaller, 1911, Amer. Journ. Sci., XXXII, p. 251.

Hodgkinsonite

a: b: c = 1.538.1:1.1075 $\beta = 84° 35'$

c	0	001	Franklin Furnace, N. J.	1
l	2∞	210	" " "	1
m	∞	110	" " "	1
s	01	011	" " "	1
o	02	021	" " "	1
x	$-\frac{3}{5}0$	$\bar{3}05$	" " "	1
v	$-\frac{4}{3}0$	$\bar{4}03$	" " "	1
w	—20	$\bar{2}01$	" " "	1
t	—40	$\bar{4}01$	" " "	1
p	1	111	" " "	1
u	$-\frac{3}{2}$	$\bar{3}22$	" " "	1
r	2	221	" " "	1
q	$\frac{5}{2}$	552	" " "	1
n	—31	$\bar{3}11$	" " "	1

1.—C. Palache and W. T. Schaller, 1913, Journ. Wash. Acad. Sci., III, p. 474; 1914, idem, IV, p. 153.

Hoegbonite

Hexagonal Trigonal $a:c = 1:1.156$

c	0	0001	Kvikkjokk, Norrbotten, Sweden			1
	10	$10\bar{1}1$	"	"	"	1
	20	$20\bar{2}1$	"	"	"	1

1.—A. Gavelin, 1916, Bull. Geol. Univ. Upsala, XV, p. 289.

Hopeite

$a:b:c = 0.5703:1:0.4720$ (Walker)

	2∞	210	Broken Hill, Rhodesia, Africa			3
	$\infty\frac{6}{7}$	670	Salmo, British Columbia			4
i	$\infty\frac{1}{5}\frac{1}{1}$	5.11.0	Broken Hill, Rhodesia, Africa			2
	$\infty 2$	120	"	"	"	3
	$\infty 3$	130	Moresnet, Belgium			1
	$\infty\frac{1}{3}\frac{1}{1}$	3.11.0	Salmo, British Columbia			4
	$0\frac{2}{5}$	025	Broken Hill, Rhodesia, Africa			3
	$0\frac{5}{6}$	056	"	"	"	3
	$0\frac{5}{4}$	054	"	"	"	3
	$0\frac{3}{2}$	032	"	"	"	3
	02	021	Salmo, British Columbia			4
	$\frac{1}{9}$	119	Broken Hill, Rhodesia, Africa			3
	$\frac{1}{7}$	117	"	"	"	3
	$\frac{1}{6}$	116	"	"	"	3
	$\frac{1}{4}$	114	"	"	"	3
	$\frac{3}{1\,1}$	3.3.11	"	"	"	3
	$\frac{3}{1\,0}$	3.3.10	"	"	"	3
	12	121	"	"	"	3
q	$\frac{2}{3}1$	233	"	"	"	2
t	$\frac{1}{3}1$	133	"	"	"	2
	$\frac{1}{2}\frac{3}{2}$	132	"	"	"	3
	$\frac{1}{2}2$	142	"	"	"	3

1.—H. Buttgenbach, 1906, Ann. Soc. Géol. Belg., XXXIII, p. M9
2.—L. J. Spencer, 1908, Min. Mag., XV, p. 5.
3.—H. Ungemach, 1910, Bull. Soc. fr. Min., XXXIII.
4.—T. L. Walker, 1916, Journ. Wash. Acad. Sci., VI, p. 685.

Hügelite

$a:b:c = 0.48954:1:0.38372 \quad \beta = 60°\ 12'$

c	0	001	Reichenbach, Baden, Ger.			1
m	∞	100	"	"	"	1
n	01	011	"	"	"	1

1.—V. Dürrfeld, 1912, Zeitschr. f. Kryst., LI, p. 276; 1913, idem, LIII, p. 183.

Hulsite

a: b: c = 0.5501:1:? (Orthorhombic?)

c	0	001	Seward Peninsula, Alaska			1
a	∞0	100	"	"	"	1
b	0∞	010	"	"	"	1
m	∞	110	"	"	"	1

1.—A. Knopf and W. T. Schaller, 1908, Amer. Journ. Sci., XXV, p. 325.

Humboldtine

a: b: c = 0.7730:1:1.1039

	0	001	Capo d'Arco, Elba, Italy			1
	∞0	100	"	"	"	1
	∞	110	"	"	"	1
	10	101	"	"	"	1

1.—Manasse; 1910, Rend. Accad. Linc., XIX (2), p. 138.

Humite Group, Chondrodite

	$\frac{1}{5}$	115	Nordmark, Sweden	1
	$-\frac{1}{5}$	$\bar{1}15$	" "	1
	$-\frac{1}{2}$	$\bar{1}12$	" "	1
	$-1\frac{1}{2}$	$\bar{2}12$	" "	1
	$\frac{3}{7}\ \frac{2}{7}$	327	" "	1
	$\frac{3}{11}\ \frac{2}{11}$	3.2.11	" "	1

1.—H. Sjögren, 1892, Geol. Fören. Förh., XIV, p. 423.

Humite Group, Prolectite

a: b: c = 1.0803:1:1.8862 $\beta = 90°$

A	0	001	Nordmark, Sweden		1
B	0∞	010	"	"	1
	∞	110	"	"	1
	$0\frac{1}{4}$	014	"	"	1
	$0\frac{1}{2}$	012	"	"	1
	$\frac{1}{3}0$	103	"	"	1
	$\frac{5}{3}0$	503	"	"	1
	$-\frac{4}{9}0$	$\bar{4}09$	"	"	1
	$\frac{3}{7}$	337	"	"	1
	-1	$\bar{1}11$	"	"	1
	$-\frac{2}{3}$	$\bar{2}23$	"	"	1
	$-\frac{2}{7}$	$\bar{2}27$	"	"	1
	$-\frac{2}{9}$	$\bar{2}29$	"	"	1

	—12	$\bar{1}21$	Nordmark, Sweden	1
	12	121	" "	1
	31	322	" "	1

1.—H. Sjögren, 1894, Bull. Geol. Inst., Upsala.

Hutchinsonite

a: b: c = 1.6343:1:0.7549

c	0	001	Binnenthal, Switzerland	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
	$\frac{16}{5} \infty$	16.5.0	" "	1
H	$\frac{8}{3} \infty$	830	" "	2
G	$\frac{7}{3} \infty$	730	" "	2
	$\frac{16}{7} \infty$	16.7.0	" "	1
F	2∞	210	" "	1
l	$\frac{7}{4} \infty$	740	" "	1
k	$\frac{3}{2} \infty$	320	" "	1
i	$\frac{5}{4} \infty$	540	" "	1
m	∞	110	" "	1
h	$\infty \frac{4}{3}$	340	" "	1
f	$\infty 2$	120	" "	1
k	$\infty \frac{5}{2}$	250	" "	2
g	$\infty 4$	140	" "	1
	01	011	" "	1
Z	60	601	" "	2
Y	50	501	" "	1
w	40	401	" "	1
v	30	301	" "	1
X	$\frac{7}{3}0$	703	" "	2
ω	20	201	" "	1
W	$\frac{3}{2}0$	302	" "	1
d	10	101	" "	1
V	$\frac{3}{4}0$	304	" "	2
U	$\frac{1}{2}0$	102	" "	1
p	1	111	" "	1
A	$\frac{3}{2}$	332	" "	2
N	2	221	" "	2
n	12	121	" "	2
O	$\frac{1}{4}1$	144	" "	2
r	$\frac{1}{2}1$	122	" "	1

q	$\frac{3}{2}1$	322	Binnenthal, Switzerland	1
o	21	211	" "	1
P	$\frac{5}{2}1$	522	" "	2
Q	31	311	" "	1
R	41	411	" "	2
x	$\frac{5}{4}\,\frac{1}{2}$	524	" "	2
C	$\frac{3}{2}\,\frac{1}{2}$	312	" "	2
S	$\frac{1}{2}2$	142	" "	2
t	$\frac{3}{2}2$	342	" "	2
T	$\frac{7}{2}2$	742	" "	2

1.—R. H. Sólly, 1905, Min. Mag., XIV, p. 72.
2.—G. F. H. Smith and G. T. Prior, 1907, Min. Mag., XIV, p. 284.

Hyalophane

$\infty\frac{8}{3}$	380	Binnenthal, Switzerland	1
$-1\frac{1}{2}$	$\bar{2}12$	" "	1
-21	$\bar{2}11$	" "	1

1.—R. H. Solly, 1904, Min. Mag., XIV, p. 17.

Hydrocerussite

Hexagonal $a:c=1:1.4188$

c	0	0001	Långban, Sweden	1
p	10	$10\bar{1}1$	" "	1
o	$\frac{1}{2}0$	$10\bar{1}2$	" "	1

1.—G. Flink, 1901, Bull. Geol. Inst. Upsala, V, p. 94.

Ilmenite

$\hat{\delta}$	2∞	$21\bar{3}0$	Quincy, Mass.	4
h	4∞	$41\bar{5}0$	Binnenthal, Switzerland	3
d	$\frac{1}{2}0$	$10\bar{1}2$	" "	3
φ	$\frac{4}{7}0$	$40\bar{4}7$	Val Devero, Piedmont, Italy	5
Γ	40	$40\bar{1}4$	Binnenthal, Switzerland	3
g	$-\frac{3}{1\,1}0$	$0.3.\bar{3}.11$	Quincy, Mass.	4
	$-\frac{3}{1\,0}0$	$0.3.\bar{3}.10$	" "	4
	$-\frac{4}{1\,1}0$	$0.4.\bar{4}.11$	Beaume (Dora Riparia), Piedmont, Italy	1
α	$-\frac{7}{2\,0}0$	$0.7.\bar{7}.20$	Binnenthal, Switzerland	3
Ψ	$-\frac{2}{7}0$	$02\bar{2}7$	Beaume (Dora Riparia), Piedmont, Italy	1

Λ	$-\frac{4}{5}0$	$04\bar{4}5$	Quincy, Mass.	4
λ	$-\frac{5}{2}0$	$05\bar{5}2$	" "	4
β	$\frac{5}{2}\frac{}{4}$	$5.5.\bar{1}0.24$	Binnenthal, Switzerland	3
	$\frac{1}{2}$	$11\bar{2}2$	Beaume (Dora Riparia), Piedmont, Italy	1
χ	$\frac{4}{3}$	$44\bar{8}3$	Binnenthal, Switzerland	3
χ^1	$-\frac{4}{3}$	$8\bar{4}43$	Val Devero, Piedmont, Italy	5
y	$\frac{3}{2}\frac{1}{2}$	$31\bar{4}2$	Eichamwand, Prägratem, Tyrol	2
γ	$\frac{1}{2}1$	$12\bar{3}2$	Binnenthal, Switzerland	3
δ	$\frac{2}{7}\frac{4}{7}$	$24\bar{6}7$	" "	3
q	24	$24\bar{6}1$	" "	3
κ	12	$12\bar{3}1$	" "	3

1.—G. Piolte, 1902, Atti. Acc. Sci. Turin, XXXVII.
2.—P. P. Sustschinsky, 1902, Zeitschr. f. Kryst., XXXVIII, p. 60.
3.—R. H. Solly, 1905, Min. Mag., XIV, p. 184.
4.—C. Palache and C. H. Warren, 1911, Amer. Journ. Sci., XXXI, p. 553.
5.—L. Magistretti, 1912, Rend. Accad. Linc., XXI, p. 261.

Ilvaite

γ	$\infty 6$	160	Tunugdliarfik-Fjord, S. Greenland	1
σ	08	081	" "	1
f	04	041	" "	1
i	40	401	" "	1
ξ	3	331	" "	1
m	62	621	" "	1
ϵ	43	431	" "	1

1.—O. B. Böggild, 1902, Medd. om Grönland, XXV, p. 45.

Inesite

k	$-\frac{1}{1}\frac{1}{2}0$	$\bar{1}1.0.12$	Durango, Mexico	2
f	-30	$\bar{3}01$	Nordmark, Sweden	1
s	$-\frac{3}{2}\frac{2}{3}$	$9\bar{4}6$	Durango, Mexico	2

1.—A. Hamberg, 1894, Geol. Fören. Förh., XVI, p. 323.
2.—O. C. Farrington, 1900, Field Col. Mus. Pub., I (VII), p. 221.

Inyoite

$a:b:c = 0.9408:1:0.6665 \quad \beta = 62° 37'$

c	0	001	Death Valley, Calif.	1
b	0∞	010	" " "	1

m	∞	100	Death Valley, Calif.	1
p	1	111	" " "	1

1.—W. T. Schaller, 1916, U. S. Geol. Surv., Bull. DCX, p. 37.

Iodyrite

z	$\frac{3}{2}0$	$30\bar{3}2$?	Tonopah, Nevada	1
r	$\frac{7}{4}0$	$70\bar{7}4$?	" "	1
s'	$\frac{15}{8}0$	$15.0.\bar{15}.8$?	" "	1
t	$\frac{7}{3}0$	$70\bar{7}3$?	" "	1
w	$\frac{9}{2}0$	$90\bar{9}2$?	" "	1
w'	$-\frac{9}{2}0$	$90\bar{9}\bar{2}$?	" "	1
x	70	$70\bar{7}1$?	" "	1
y	90	$90\bar{9}1$?	" "	1
y'	—90	$90\bar{9}\bar{1}$?	" "	1

1.—E. H. Kraus and C. W. Cook, 1909, Amer. Journ. Sci., XXVII, p. 210.

Iolite

$\infty\frac{5}{3}$	350	Montavon Valley, Switzerland		1
$\infty 2$	120	"	"	" 1
$\infty 6$	160	"	"	" 1
50	501	"	"	" 1
$1\frac{1}{2}$	212	"	"	" 1
35	351	"	"	" 1
26	261	"	"	" 1
$\frac{4}{3}4$	4.12.3	"	"	" 1
28	281	"	"	" 1
3.18	3.18.1	"	"	" 1
$\frac{1}{4}\,\frac{3}{2}$	164	"	"	" 1
$\frac{1}{8}\,\frac{3}{4}$	168	"	"	" 1

1.—H. Gemböck, 1898, Zeitschr. f. Kryst., XXIX, p. 305.

Jamesonite

a: b: c = 0.8316:1:0.4260 $\beta = 91° 24'$

c	0	001	Kasejovic, Bohemia	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
l	2∞	210	" "	1
m	∞	110	" "	1
n	$\infty 2$	120	" "	1
f	$0\frac{1}{2}$	012	" "	1

g	$0\frac{3}{2}$	032?	Kasejovic, Bohemia		1
e	01	011	"	"	1
d	—10	$\bar{1}01$	"	"	1
r	$-\frac{1}{2}$	$\bar{1}12$	"	"	1
o	—1	$\bar{1}11$	"	"	1
q	$-1\frac{1}{2}$	$\bar{2}12$	"	"	1
s	$-1\frac{3}{2}$	$\bar{2}32$	"	"	1

1.—O. Hofmann and F. Slavic, 1913, Abh. d. böhm. Akad., XIX, p. 21.

Ježekite

a: b: c = 0.8959:1:1.0241 $\beta = 105° 31\frac{1}{2}'$

c	0	001	Ehrenfriedersdorf, Saxony		1
a	∞0	100	"	"	1
b	0∞	010	"	"	1
m	∞	110	"	"	1
r	$0\frac{1}{2}$	012	"	"	1
q	01	011	"	"	1
g	$\frac{1}{4}0$	104	"	"	1
d	$\frac{1}{2}0$	102	"	"	1
e	—10	$\bar{1}01$	"	"	1

1.—F. Slavic, 1914, Abh. d. böhm. Akad., XX.

Johannite

a: b: c = 1.0527:1:1.395 $\beta = 95° 42'$

c	0	001	Joachimsthal, Bohemia		1
n	∞2	120	"	"	1
f	$\frac{15}{8}0$	15.0.8	"	"	1
d	20	201	"	"	1
p	$\frac{1}{4}\,\frac{1}{2}$	124	"	"	1

1.—B. Ježek, 1915, Abh. d. böhm. Akad., XXI.

Jordanite

c	0	001	Binnenthal, Switzerland		1
a	∞0	100	"	"	1
b	0∞	010	"	"	1
	5∞	510	"	"	2
4*s*	4∞	410	"	"	1
	3∞	310	"	"	2
2*s*	2∞	210	"	"	1
r	∞	110	"	"	1

$\frac{7}{6}r$	$\infty\frac{7}{6}$	670	Binnenthal, Switzerland		1
$\frac{5}{4}r$	$\infty\frac{5}{4}$	450	"	"	1
	$\infty\frac{4}{3}$	340	"	"	2
$\frac{3}{2}r$	$\infty\frac{3}{2}$	230	"	"	1
$2r$	$\infty 2$	120	"	"	1
$\frac{2}{1}\frac{7}{2}r$	$\infty\frac{2}{1}\frac{7}{2}$	12.27.0	"	"	1
$\frac{7}{3}r$	$\infty\frac{7}{3}$	370	"	"	1
$\frac{5}{2}r$	$\infty\frac{5}{2}$	250	"	"	1
$\frac{1}{4}\frac{1}{}r$	$\infty\frac{1}{4}\frac{1}{}$	4.11.0	"	"	1
$3r$	$\infty 3$	130	"	"	1
$\frac{2}{7}\frac{4}{}r$	$\infty\frac{2}{7}\frac{4}{}$	7.24.0	"	"	1
$\frac{7}{2}r$	$\infty\frac{7}{2}$	270	"	"	1
$\frac{3}{9}\frac{2}{}r$	$\infty\frac{3}{9}\frac{2}{}$	9.32.0	"	"	1
$4r$	$\infty 4$	140	"	"	1
$\frac{4}{1}\frac{9}{2}r$	$\infty\frac{4}{1}\frac{9}{2}$	12.49.0	"	"	1
$\frac{9}{2}r$	$\infty\frac{9}{2}$	290	"	"	1
$5r$	$\infty 5$	150	"	"	1
$\frac{1}{2}\frac{1}{}r$	$\infty\frac{1}{2}\frac{1}{}$	2.11.0	"	"	1
$\frac{1}{2}\frac{5}{}r$	$\infty\frac{1}{2}\frac{5}{}$	2.15.0	"	"	1
$8r$	$\infty 8$	180	"	"	1
$\frac{7}{2}k$	$0\frac{7}{2}$	072	"	"	1
$3k$	03	031	"	"	1
$\frac{5}{2}k$	$0\frac{5}{2}$	052	"	"	1
$2k$	02	021	"	"	1
$\frac{3}{2}k$	$0\frac{3}{2}$	032	"	"	1
k	01	011	"	"	1
$\frac{1}{2}k$	$0\frac{1}{2}$	012	"	"	1
$-5h$	50	501	"	"	1
$-3h$	30	301	"	"	1
$-2h$	20	201	"	"	1
$-h$	10	101	"	"	1
h	-10	$\bar{1}01$	"	"	1
$2h$	-20	$\bar{2}01$	"	"	1
$3h$	-30	$\bar{3}01$	"	"	1
$5h$	-50	$\bar{5}01$	"	"	1
p	1	111	"	"	1
$-p$	-1	$\bar{1}11$	"	"	1
$-3p$	3	331	"	"	1
$3p$	-3	$\bar{3}31$	"	"	1
$\frac{2}{3}\frac{8}{}t$	$-1\frac{3}{2}\frac{}{8}$	$\overline{28}.3.28$	"	"	1

—2t	$1\frac{1}{2}$	212	Binnenthal, Switzerland	1
2t	—$1\frac{1}{2}$	$\bar{2}12$	" "	1
	$1\frac{3}{2}$	232	" "	2
—2q	12	121	" "	1
2q	—12	$\bar{1}21$	" "	1
	—$1\frac{5}{2}$	$\bar{2}52$	" "	2
—3q	13	131	" "	1
3q	—13	$\bar{1}31$	" "	1
—$\frac{7}{2}q$	$1\frac{7}{2}$	272	" "	1
$\frac{7}{2}q$	—$1\frac{7}{2}$	$\bar{2}72$	" "	1
—4q	14	141	" "	1
4q	—14	$\bar{1}41$	" "	1
	$1\frac{9}{2}$	292	" "	2
—5q	15	151	" "	1
5q	—15	$\bar{1}51$	" "	1
	$1\frac{1}{2}$	2.11.2	" "	2
—6q	16	161	" "	1
6q	—16	$\bar{1}61$	" "	1
—7q	17	171	" "	1
7q	—17	$\bar{1}71$	" "	1
—8q	18	181	" "	1
8q	—18	$\bar{1}81$	" "	1
—9q	19	191	" "	1
9q	—19	$\bar{1}91$	" "	1
—10q	1.10	1.10.1	" "	1
10q	—1.10	$\bar{1}$.10.1	" "	1
12q	—1.12	$\bar{1}$.12.1	" "	1
	—1.13	$\bar{1}$.13.1	" "	2
	—1.14	$\bar{1}$.14.1	" "	2
—17q	1.17	1.17.1	" "	1
	—1.17	$\bar{1}$.17.1	" "	2
18q	—1.18	$\bar{1}$.18.1	" "	1
—3w	31	311	" "	1
3w	—31	$\bar{3}11$	" "	1
—2w	21	211	" "	1
2w	—21	$\bar{2}11$	" "	1
—6x	36	361	" "	1
6x	—36	$\bar{3}61$	" "	1
—5x	35	351	" "	1
5x	—35	$\bar{3}51$	" "	1

$-7x$	37	371	Binnenthal, Switzerland	1
$-8x$	38	381	" "	1
$-4x$	34	341	" "	1
$4x$	-34	$\bar{3}41$	" "	1
$3z$	-23	$\bar{2}31$	" "	1
$\frac{5}{2}z$	$-2\frac{5}{2}$	$\bar{4}52$	" "	1
	$2\frac{3}{2}$	432	" "	2
$-5v$	52	521	" "	1
$-3v$	32	321	" "	1
$3v$	-32	$\bar{3}21$	" "	1
$-2y$	$2\frac{1}{2}$	$\bar{4}12$	" "	1
$2y$	$-2\frac{1}{2}$	$\bar{4}12$	" "	1

1.—H. Baumhauer, 1891, Sitz. Ber. Akad., pp. 697, 915.
2.—R. H. Solly, 1901, Zeitschr. f. Kryst., XXXV, p. 321.

Kainite

u	5∞	510	Stassfurt, Germany	1
f	$\infty\frac{4}{3}$	340	" "	1
g	$\infty\frac{3}{2}$	230	" "	1
h	$\infty 3$	130	" "	1
i	02	021	" "	1
w'	-31	$\bar{3}11$	" "	1

1.—C. Busz, 1906, Ber. Med.-naturw. Ges., Münster.

Kaolinite

	02	021	Silverton, Colo.	1

1.—A. Johnsen, 1911, Centralb. f. Min., p. 23.

Kentrolite

e	$\frac{1}{2}0$	102	Jacobsberg, Sweden	1
u	$\frac{1}{4}$	114	" "	1
v	$\frac{1}{5}$	115	" "	1
z	$\frac{3}{1\,0}\,\frac{3}{2}$	3.15.10	" "	1

1.—G. Nordenskiöld, 1894, Geol. Fören. Förh., XVI, p. 153.

Kermesite

$a:b:c = 4.6448:1.1717:1 \quad \beta = 90°$

α	$\frac{2}{5}0$	205	Pernec, Hungary	1
β	$\frac{1}{2}0$	102	" "	1
γ	$\frac{2}{3}0$	203	" "	1

ϵ	$\frac{9}{8}0$	908	Pernec, Hungary	1
κ	$\frac{7}{4}0$	704	" "	1
μ	$\frac{5}{2}0$	502	" "	1
τ	80	801	" "	1

1.—Pjatnitzky, 1892, Zeitschr. f. Kryst., XX, p. 422.

Kieserite

$a:b:c = 0.9046:1:1.7739 \quad \beta = 88° \ 55\frac{1}{2}'$

c	0	001	Westeregln, Saxony	1
y	$\frac{3}{5}$	335	" "	1

1.—H. Bücking, 1895, Sitz. Ber. Akad., p. 533.

Kleinite

Hexagonal $a:c = 1:1.6642$

c	0	0001	Terlingua, Texas	1
m	$\infty 0$	$10\bar{1}0$	" "	1
a	∞	$11\bar{2}0$	" "	1
p	10	$10\bar{1}1$	" "	1
x	$\frac{1}{2}0$	$10\bar{1}2$	" "	2

1.—A. Sachs, 1905, Sitz. Ber. Akad., p. 1091.
2.—W. F. Hillebrand and W. T. Schaller, 1909, U. S. Geol. Surv., Bull. CDV.

Knopite

Isometric

	$\infty 0$	100	Alno, Sweden	1
	1	111	" "	1
	$\frac{9}{2}0$	920	" "	1
	91	911	" "	1

1.—P. J. Holmquist, 1894, Geol. Fören. Förh., XVI, p. 73.

Koechlinite

$a:b:c = 0.9774:1:1.0026$

a	$\infty 0$	100	Schneeberg, Saxony	1
b	0∞	010	" "	1
k	2∞	210	" "	1
h	$\frac{4}{3}\infty$	430	" "	1
m	∞	110	" "	1
j	$\infty\frac{5}{4}$	450	" "	1
n	$\infty\frac{3}{2}$	230	" "	1
l	$\infty 3$	130	" "	1

p	1	111	Schneeberg, Saxony	1
u	13	131	" "	1
r	$\frac{3}{2}1$	322	" "	1
s	$\frac{5}{3}1$	533	" "	1
x	$\frac{3}{2}3$	362	" "	1

1.—W. T. Schaller, 1916, U. S. Geol. Surv., Bull. DCX, p. 10.

Krennerite

a: b: c = 0.9369:1:0.5068

K	3∞	310	Nagyag, Hungary	1
L	$\frac{5}{2}\infty$	520	" "	1
M	$\frac{6}{5}\infty$	650	" "	1
N	$\infty\frac{4}{3}$	340	" "	1
j	$\infty 4$	140	" "	1
J	$\infty 6$	160	" "	1
δ	$0\frac{4}{3}$	043	" "	1
Θ	$0\frac{5}{4}$	054	" "	1
μ	$\frac{1}{4}0$	104	" "	1
Π	$\frac{5}{2}0$	502	" "	1
π	40	401	" "	1
λ	90	901	" "	1
β	14	141	" "	1
φ	$1\frac{4}{3}$	343	" "	1
χ	$\frac{1}{4}1$	144	" "	1
Ψ	$\frac{3}{4}1$	344	" "	1
ξ	41	411	" "	1
γ	58	581	" "	1
f	23	231	" "	1
α	$\frac{5}{2}3$	562	" "	1
r	$\frac{1}{2}2$	142	" "	1
x	$\frac{3}{2}2$	342	" "	1
R	$\frac{5}{2}2$	542	" "	1

1.—G. F. Herbert-Smith, 1903, Min. Mag., XIII, p. 264.

Kröhnkite

a: b: c = 0.5229:1:0.4357 $\beta = 56° 17'$

a	$\infty 0$	100	Chuquicamata, Chile	1
b	0∞	101	" "	1
h	$\infty 2$	120	" "	1
k	$\infty 3$	130	" "	1

e	01	011	Chuquicamata, Chile		1
d	02	021	"	"	1
f	03	031	"	"	1
t	—10	$\bar{1}01$	"	"	1
u	$-\frac{3}{2}0$	$\bar{3}02$	"	"	1.
v	—30	$\bar{3}01$	"	"	1
p	1	111	"	"	1
q	—1	$\bar{1}11$	"	"	1
x	—2	$\bar{2}11$	"	"	1
z	—3	$\bar{3}11$	"	"	1
i	—5	$\bar{5}11$	"	"	1
o	—10	$\overline{10}.10.1$	"	"	1
r	12	121	"	"	1
s	—12	$\bar{1}21$	"	"	1
y	$-1\frac{3}{2}$	$\bar{2}32$	"	"	1
w	—21	$\bar{2}11$	"	"	1
n	$-\frac{1}{2}\ \frac{3}{2}$	$\bar{1}32$	"	"	1

1.—C. Palache and C. H. Warren, 1908, Amer. Journ. Sci., XXVI, p. 342.

Lacroixite

a: b: c = 0.82:1:1.60 β = ?

b	0∞	010	Ehrensfriedersdorf, Saxony		1
m	∞	110	"	"	1
p	1	111	"	"	1

1.—F. Slavic, 1914, Abh. d. böhm. Akad., No. VI.

Långbanite

Hexagonal Rhombohedral *a: c* = 1:1.4407

c	0	0001	Långban, Sweden		1
m	∞0	$10\bar{1}0$	"	"	1
σ	—2∞	$3\bar{1}\bar{2}0$	"	"	1
s	2∞	$21\bar{3}0$	"	"	1
n	∞	$11\bar{2}0$	"	"	1
k	$\frac{2}{9}$	$22\bar{4}9$	"	"	1
π	$\frac{1}{3}$	$11\bar{2}3$	"	"	1
p	$-\frac{1}{3}$	$2\bar{1}\bar{1}3$	"	"	1
o	$\frac{2}{3}$	$22\bar{4}3$	"	"	1
ω	$-\frac{2}{3}$	$4\bar{2}\bar{2}3$	"	"	1
d	$\frac{4}{3}$	$44\bar{8}3$	"	"	1
e	$\frac{1}{3}0$	$10\bar{1}3$	"	"	1

f	$\frac{2}{3}0$	$20\bar{2}3$	Långban, Sweden		1
g	$\frac{4}{3}0$	$40\bar{4}3$	"	"	1
γ	$0\frac{4}{3}$	$04\bar{4}3$	"	"	1
φ	$0\frac{2}{3}$	$02\bar{2}3$	"	"	1
ε	$0\frac{1}{3}$	$01\bar{1}3$	"	"	1
l	$\frac{4}{3}\frac{2}{3}$	$42\bar{6}3$	"	"	1
i	$\frac{2}{3}\frac{1}{3}$	$21\bar{3}3$	"	"	1
h	$\frac{8}{3}\frac{2}{3}$	8.2.10.3	"	"	1

1.—G. Flink, 1910, Ark. Kemi. Min. Geol., III, p. 1.

Langbeinite

Isometric Tetartohedral

a	$\infty 0$	100	Saxony, Anhalt, Brunswick, Ger.			1
y	$\frac{9}{2}\infty$	920	"	"	"	" 1
f	3∞	310	"	"	"	" 1
e	2∞	210	"	"	"	" 1
d	∞	110	"	"	"	" 1
o	1	111	"	"	"	" 1
o_1	—1	$\bar{1}11$	"	"	"	" 1
p_1	—2	$2\bar{2}1$	"	"	"	" 1
n	—21	$2\bar{1}1$	"	"	"	" 1

1.—O. Luedecke, 1898, Zeitschr. f. Kryst., XXIX, p. 255.

Laurionite

a: b: c = 0.7385:1:0.8346

o	$\frac{1}{2}$	112	Laurium, Greece		1
q	2	221	"	"	1
u	$1\frac{3}{2}$	232	"	"	1
r	$\frac{1}{2}\frac{3}{2}$	132	"	"	1
s	$\frac{1}{2}2$	142	"	"	1
t	$\frac{1}{2}\frac{5}{2}$	152	"	"	1

1.—G. F. Herbert-Smith, 1900, Min. Mag., XII, p. 102.

Lautite

a: b: c = 0.69124:1:1.0452

c	0	001	Markirch, Alsace		1
o	$\infty\frac{3}{2}$	230	"	"	1
v	$0\frac{3}{2}$	032	"	"	1
f	$\frac{3}{5}0$	305	"	"	1

e	10	101	Narkirch, Alsace			1
x	2	221	"	"		1
t	$\frac{10}{13}$	10.10.13	"	"		1
v	$1\frac{1}{4}$	414	"	"		1
l	$1\frac{2}{3}$	323	"	"		1
g	$1\frac{3}{2}$	232	"	"		1
u	$\frac{1}{2}1$	112	"	"		1
r	$2\frac{2}{3}$	623	"	"		1
n	$2\frac{4}{3}$	643	"	"		1
k	$\frac{5}{4}\frac{5}{6}$	15.10.12	"	"		1
s	$\frac{25}{16}\frac{45}{32}$	50.45.32	"	"		1
h	$\frac{2}{3}\frac{4}{3}$	243	"	"		1
i	$\frac{9}{20}\frac{3}{2}$	9.30.20	"	"		1
μ	$\frac{2}{3}\frac{10}{9}$	6.10.9	"	"		1
ζ	$\frac{3}{10}3$	3.30.10	"	"		1

1.—V. Dürrfeld, 1909, Mitth. d. geol. Land. Els.-Lothr., VII, p. 121.

Lawsonite

a: b: c = 0.6652:1:0.7385

	o	001	Tiburon Peninsula, Calif.			1
	∞	110	"	"	"	1
	01	011	"	"	"	1
	04	041	"	"	"	1
r	2	221	"	"	"	2
s	3	331	"	"	"	2

1.—F. L. Ransome, 1895, Bull. Univ. Calif. (Geol.), I, p. 301.
2.—W. T. Schaller and W. F. Hillebrand, 1904, Amer. Journ. Sci., XVII, p. 195.

Leadhillite

a: b: c = 0.8742:1:1.1122 $\beta = 89° 30'$

j	4∞	410	Searchlite, Lincoln Co., Nev.			2
L	$\frac{4}{3}\infty$	430	Sardinia			1
v	$0\frac{1}{4}$	014	Tintic Dist., Utah			2
χ	$0\frac{1}{3}$	013	"	"	"	2
η	$0\frac{2}{3}$	023	"	"	"	2
Γ	$0\frac{3}{4}$	034	"	"	"	2
π	$0\frac{5}{3}$	053	"	"	"	2
φ	02	021	"	"	"	2
Ψ	$0\frac{5}{2}$	052	"	"	"	2
Λ	03	031	"	"	"	2

y	40	401	Sardinia	1
z	$\frac{3}{2}0$	302	"	1
C	$\frac{4}{3}0$	403	Searchlite, Lincoln Co., Nev.	2
f	—10	$\bar{1}01$	Sardinia	1
E	$-\frac{2}{3}0$	$\bar{2}03$	Tintic Dist., Utah	2
β	$\frac{1}{3}$	113	Sardinia	1
P	$-\frac{1}{2}$	$\bar{1}12$	Tintic Dist., Utah	2
x	—2	$\bar{2}21$	" " "	2
ϑ	$1\frac{3}{4}$	434	Sardinia	1
I	$1\frac{5}{2}$	252	Searchlite, Lincoln Co., Nev.	2
K	13	131	" " "	2
A	$-1\frac{5}{2}$	$\bar{2}52$	Tintic Dist., Utah	2
G	—13	$\bar{1}31$	" " "	2
S	—14	$\bar{1}41$	Searchlite, Lincoln Co., Nev.	2
V	$-1\frac{9}{2}$	$\bar{2}92$	" " "	2
Y	—21	$\bar{2}11$	Tintic Dist., Utah	2
τ	$-\frac{4}{7}1$	$\bar{4}77$	Sardinia	1
γ	$3\frac{1}{2}$	612	"	1
ζ	$-2\frac{1}{2}$	$\bar{4}12$	"	1
W	$-2\frac{3}{2}$	$\bar{4}32$	Tintic Dist., Utah	2
M	$-2\frac{5}{2}$	$\bar{4}52$	" " "	2
Z	—23	$\bar{2}31$	Searchlite, Lincoln Co., Nev.	2
R	—24	$\bar{2}41$	Tintic Dist., Utah	2
Σ	$-\frac{3}{2}\frac{1}{4}$	$\bar{6}14$	Searchlite, Lincoln Co., Nev.	2
σ	$-\frac{2}{3}\frac{1}{2}$	$\bar{4}36$	Sardinia	1
δ	$\frac{1}{2}\frac{1}{8}$	418	"	1
ϵ	$\frac{1}{2}\frac{1}{4}$	214	"	1
N	$\frac{1}{2}\frac{5}{8}$	458	Tintic Dist., Utah	2
Ψ	$\frac{1}{2}\frac{3}{4}$	234	Searchlite, Lincoln Co., Nev.	2
Ω	$\frac{1}{2}\frac{3}{2}$	132	" " "	2
μ	$-\frac{1}{2}\frac{1}{8}$	$\bar{4}18$	Sardinia	1
Q	$-\frac{1}{2}\frac{3}{4}$	$\bar{2}34$	Tintic Dist., Utah	2
T	$-\frac{1}{2}\frac{5}{4}$	$\bar{2}54$	" " "	2
U	$-\frac{1}{3}\frac{1}{2}$	$\bar{2}36$	" " "	2
Φ	$\frac{1}{3}\frac{5}{6}$	256	Searchlite, Lincoln Co., Nev.	2
λ	$-\frac{1}{3}\frac{1}{1}\frac{1}{2}$	$\bar{4}.1.12$	Sardinia	1
B	$-\frac{1}{3}\frac{2}{3}$	$\bar{1}23$	Tintic Dist., Utah	2
O	$-\frac{7}{8}\frac{3}{4}$	$\bar{7}68$	Searchlite, Lincoln Co., Nev.	2

1.—E. Artini, 1890, Giorn. d. Min., I, p. 1.
2.—C. Palache and L. LaForge, 1909, Proc. Amer. Acad. Sci., XLIV, pp. 435, 452.

Leonite

$a:b:c = 1.03855:1:1.23365 \quad \beta = 84° 50'$

c	0	001	Westeregeln, Leopoldshall, Ger.			1
b	0∞	010	"	"	"	1
μ	$\infty 2$	120	"	"	"	1
o	$0\frac{1}{3}$	013	"	"	"	1
n	01	011	"	"	"	1
w	10	101	Leopoldshall, Ger.			2
d	$\frac{1}{2}0$	$\bar{1}02$	Westeregeln, Leopoldshall, Ger.			1
δ	$-\frac{1}{2}0$	$\bar{1}02$	"	"	"	1
q	$\frac{1}{3}$	113	"	"	"	1
p	1	$\bar{1}11$	"	"	"	1
π	—1	$\bar{1}11$	"	"	"	1
	—21	$\bar{2}11$	Leopoldshall, Ger.			2

1.—C. A. Tenne, 1896, Zeitschr. Geol. Ges., XLVIII, p. 632.
2.—J. E. Strandmark, 1902, Zeitschr. f. Kryst., XXXVI, p. 461.

Leucophoenicite

$a:b:c = 1.1045:1:2.3155 \quad \beta = 76° 44'$

c	0	001	Franklin Furnace, N. J.			1
a	$\infty 0$	100	"	"	"	1
b	0∞	010	"	"	"	1
m	∞	110	"	"	"	1
s	$\infty 2$	120	"	"	"	1
o	01	011	"	"	"	1
f	$0\frac{1}{2}$	012	"	"	"	1
e	10	101	"	"	"	1
f	$\frac{1}{2}0$	102	"	"	"	1
x	$\frac{1}{3}0$	103	"	"	"	1
y	$-\frac{1}{3}0$	$\bar{1}03$	"	"	"	1
i	$-\frac{1}{2}0$	$\bar{1}02$	"	"	"	1
r	—10	$\bar{1}01$	"	"	"	1
l	12	121	"	"	"	1
n	—12	$\bar{1}21$	"	"	"	1
u	$-\frac{1}{2}1$	$\bar{1}22$	"	"	"	1
d	$\frac{1}{3}\,\frac{2}{3}$	123	"	"	"	1
h	$-\frac{1}{3}\,\frac{2}{3}$	$\bar{1}23$	"	"	"	1
q	$\frac{1}{4}\,\frac{1}{2}$	124	"	"	"	1

1.—C. Palache, 1910, Amer. Journ. Sci., XXIX, p. 186.

Leucosphenite

a: b: c = 0.5813:1:0.8501 $\beta = 86° 37'$

c	0	001	Narsarsuk, Greenland	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
m	∞	110	" "	1
n	$\infty 3$	130	" "	1
x	01	011	" "	1
d	10	101	" "	1
s	$\frac{1}{2}$	112	" "	1
p	—1	$\bar{1}11$	" "	1
g	$\frac{1}{3}1$	133	" "	1
r	$\frac{2}{3}2$	263	" "	1

1.—G. Flink, 1898, Medd. om Grönland, XIV, p. 236; 1901, idem, XXIV, p. 137.

Lewisite

Isometric

o	1	111	Minas Geraes, Brazil	1

1.—E. Hussak and G. T. Prior, 1895, Min. Mag., XI, p. 80.

Linarite

δ	$\frac{10}{9}0$	10.0.9	Eureka, Utah	3
φ	$-\frac{9}{10}0$	$\bar{9}.0.10$	" "	3
f	21	211	Broken Hill, N. S. Wales	4
φ	31	311	" " "	4
	$\frac{7}{8}\frac{1}{8}$	718	Sardinia	1
i	$-\frac{12}{11}\frac{2}{11}$	$\bar{12}.2.11$	Cumberland, Eng.	2
f	$\frac{5}{3}\frac{2}{3}$	523	Eureka, Utah	3

1.—L. Brugnatelli, 1897, Zeitschr. f. Kryst., XXVII, p. 307.
2.—G. Cesàro, 1905, Bull. Acad. Roy. Belg., p. 328.
3.—O. C. Farrington and E. W. Tillotson, 1908, Field Col. Mus. (Geol.), III, p. 148.
4.—A. Ondrej, 1910, Abh. d. böhm. Akad., XIX, No. 37.

Lorandite

a: b: c = 1.329:1:1.0780 $\beta = 52° 27'$

c	0	001	Allchar, Macedonia	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
q	2∞	210	" "	1
ϵ	$\frac{3}{2}\infty$	320	" "	1

m	∞	110	Allchar, Macedonia		1
e	∞2	120	"	"	1
μ	∞3	130	"	"	1
u	∞4	140?	"	"	1
α	$0\frac{3}{4}$	034	"	"	1
h	$0\frac{5}{4}$	054	"	"	1
w	02	021	"	"	1
β	$-\frac{2}{5}0$	$\bar{2}05$	"	"	1
d	−10	$\bar{1}01$	"	"	1
κ	−20	$\bar{2}01$	"	"	1
v	$\frac{1}{2}$	112	"	"	1
s	$-\frac{1}{2}$	$\bar{1}12$	"	"	1
z	−1	$\bar{1}11$	"	"	1
f	$1\frac{1}{2}$	212	"	"	1
p	$-1\frac{1}{2}$	$\bar{2}12$	"	"	1
n	$-1\frac{2}{5}$	$\bar{5}25$	"	"	1
l	$\frac{1}{2}1$	122	"	"	1
k	$-\frac{3}{2}1$	$\bar{3}22$	"	"	1
r	−21	$\bar{2}11$	"	"	1
g	$\frac{4}{5}\ \frac{2}{5}$	425	"	"	1
γ	$\frac{7}{8}\ \frac{1}{2}$	748	"	"	1
j	$\frac{5}{6}\ \frac{1}{2}$	536	"	"	1
i	$\frac{3}{4}\ \frac{1}{2}$	324?	"	"	1
y	$-\frac{3}{2}\ \frac{1}{2}$	$\bar{3}12$	"	"	1
ζ	$-\frac{3}{4}\ \frac{1}{2}$	$\bar{3}24$	"	"	1
η	$-\frac{1}{5}\ \frac{1}{2}$	$\bar{2}.5.10$?	"	"	1
δ	$\frac{1}{8}\ \frac{1}{8}$	1.13.8	"	"	1

1.—V. Goldschmidt, 1898, Zeitschr. f. Kryst., XXX, p. 272.

Lorenzenite

$a:b:c = 0.6042:1:0.3592$

a	∞0	100	Narsarsuk, Greenland		1
b	0∞	010	"	"	1
m	∞	110	"	"	1
n	∞2	120	"	"	1
x	∞12	1.12.0	"	"	1
p	1	111	"	"	1
o	23	231	"	"	1

1.—G. Flink, 1898, Medd. om Grönland, XIV, p. 250; 1901, idem, XXIV, p. 130.

Lucinite

a: b: c = 0.8729:1:0.9788

c	0	001	Lucin, Boxelder Co., Utah	1
a	$\infty 0$	100	" " "	1
d	$\infty 2$	120	" " "	1
e	$0\frac{1}{2}$	012	" " "	1
r	$\frac{1}{3}$	113	" " "	1
i	$\frac{1}{2}$	112	" " "	1
p	1	111	" " "	1
s	12	121	" " "	1

1.—W. T. Schaller, 1916, U. S. Geol. Surv., Bull. DCX, p. 56.

Magnetite

	$\frac{5}{2}\infty$	520	Acquacetosa, Italy	1
Ψ	$\frac{1}{7}$	117	Split Rock, Essex Co., N. Y.	3
r	$\frac{7}{3}$	773	Gammalkroppa, Sweden	2
	3	331	Acquacetosa, Italy	1
t	5	551	Gammalkroppa, Sweden	2
	43	431	Val Malenco, Lombardy, Italy	4
	13.9	1.39.1	" " "	4

1.—F. Zambonini, 1898, Riv. Min. Ital., XXI, p. 21.
2.—G. Flink, 1910, Ark. Kemi. Min. Geol., III. p. 1.
3.—H. P. Whitlock, 1910, N. Y. State Mus., Bull. CXL, p. 199.
4.—E. Tacconi, 1911, Mem. Acc. Linc., VIII, p. 736.

Malachite

	$-\frac{4}{3}\ \frac{2}{3}$	$\bar{4}23$	Katanga, Belgian Congo, Africa	1
	$-\frac{6}{5}\ \frac{4}{5}$	$\bar{6}45$	" " " "	2

1.—G. Cesàro, 1904, Bull. Ac. Belg., p. 1206
2.—V. Dürrfeld, 1912, Zeitschr. f. Kryst., XL, p. 582.

Manganaxinite

a: b: c = 0.7797:1:0.9764 $\alpha = 91° 55'$ $\beta = 81° 51'$ $\gamma = 102° 53'$

$\mathfrak{U}$	$1\frac{5}{4}$	454	Franklin Furnace, N. J.	1

*1.—G. Aminoff, 1919, Ark. Kemi. Min., Geol., VII, No. 17.

Manganite

a: b: c = 0.8612:1:0.56289

E	$\frac{3}{2}\infty$	320	Ilefeld, Harz, Ger.	1
L	$\frac{9}{4}\infty$	940	" " "	1

R	$\infty\frac{6}{5}$	560	Ilefeld, Harz, Ger.	1
U	$\infty\frac{9}{5}$	590	" " "	1
N	$\infty\frac{7}{2}$	270	Långban, Sweden	2
U	$\frac{1}{3}0$	103	Bölet, "	2
P	$\frac{1}{3}1$	133	" "	2
Q	$\frac{4}{3}3$	493	" "	2

1.—F. Zambonini, 1901, Zeitschr. f. Kryst., XXXIV, p. 225.
2.—G. Flink, 1910, Ark. Kemi. Min. Geol., III, No. 35, p. 96.

Mangantantatite

G	$\infty 2$	120	Amelia, Virginia	1
M	$\infty\frac{5}{2}$	250	" "	1
Z	$\infty 4$	140	" "	1
D	$\infty 9$	190	" "	1
B	$\infty 13$	1.13.0	" "	1
I	$\frac{3}{2}0$	302	" "	1
U	$\frac{4}{3}$	443	" "	1
N	$2\frac{3}{2}$	432	" "	1
X	26	261	" "	1

1.—O. I. Lee and E. T. Wherry, 1919, Amer. Miner., VII, p. 80.

Marrite

$a:b:c = 0.57634:1:0.47389 \quad \beta = 88°\ 45'$

c	0	001	Binnenthal, Switzerland	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
	$\frac{7}{2}\infty$	720	" "	1
	3∞	310	" "	1
	2∞	210	" "	1
	$\frac{3}{2}\infty$	320	" "	1
	∞	110	" "	1
	$\infty\frac{3}{2}$	230	" "	1
	$\infty 2$	120	" "	1
	$\infty 3$	130	" "	1
	$\infty 4$	140	" "	1
	$\infty 5$	150	" "	1
	$\infty 7$	170	" "	1
	$0\frac{1}{3}$	013	" "	1
	$0\frac{1}{2}$	012	" "	1
	$0\frac{2}{3}$	023	" "	1

	01	011	Binnenthal, Switzerland		1
	02	021	"	"	1
	$0\frac{7}{3}$	073	"	"	1
$\frac{8}{3}k$	$0\frac{8}{3}$	083	"	"	1
	$0\frac{7}{2}$	072	"	"	1
$4k$	04	041	"	"	1
	20	201	"	"	1
	1	111	"	"	1
	$-\frac{1}{2}$	$\bar{1}12$	"	"	1
	$-\frac{2}{3}$	$\bar{2}23$	"	"	1
	-1	$\bar{1}11$	"	"	1
$-5q$	15	151	"	"	1
$-3q$	13	131	"	"	1
	12	121	"	"	1
	$1\frac{1}{2}$	212	"	"	1
	-12	$\bar{1}21$	"	"	1
	21	211	"	"	1
	-21	$\bar{2}11$	"	"	1
	$-\frac{2}{3}1$	$\bar{2}33$	"	"	1
$-v$	$\frac{3}{2}\ \frac{1}{2}$	312	"	"	1
$-w$	27	271	"	"	1

1.—R. H. Solly, 1905, Min. Mag., XIV, p. 76; 1906, idem, XIV, p. 184.

Maucherite

Tetragonal $a:c = 1.1:078$

c	0	001	Eisleben, Thuringia, Ger.		1
t	$\frac{2}{3}$	223	"	"	1
v	$\frac{4}{3}$	443	"	"	1
l	2	221	"	"	1
g	$\frac{5}{2}$	552	"	"	1
h	3	331	"	"	1
b	4	441	"	"	1
q	6	661	"	"	1

1.—A. Rosati, 1913, Rend. Accad. Linc., (V) XXII, p. 243.

Mauzellite

Isometric

a	$\infty 0$	100	Jacobsberg, Sweden		1
o	1	111	"	"	1
m	31	311	"	"	1

1.—Hj. Sjögren, 1895, Geol. Fören. Förh., XVII, p. 313.

Melanotekite

a: b: c = 0.6338:1:0.9127

a	∞0	100	Pajsberg, Sweden	1
b	0∞	010	Hillsboro, N. Mexico	2
m	∞	110	Pajsberg, Sweden	1
n	∞3	130	Hillsboro, N. Mexico	2
k	∞5	150	" "	2
d	10	101	Pajsberg, Sweden	1
o	1	111	" "	1
s	2	221	" "	1

1.—G. Nordenskiöld, 1894, Geol. Fören. Förh., XVI, p. 158.
2.—C. H. Warren, 1898, Amer. Journ. Sci., VI, p. 116.

Melanterite

l	∞2	120	Leona Heights, Alemeda Co., Calif.	1
d	$\frac{1}{2}$0	102	" " " "	1
k	$\frac{2}{3}$0	203	" " " "	1
x	$\frac{3}{2}$0	302	" " " "	1
q	20	201	" " " "	1
j	$\frac{9}{4}$0	904	" " " "	1
B	$\frac{3}{2}$	332	" " " "	1

1.—W. T. Schaller, 1903, Bull. Univ. Calif. (Geol.), III, p. 195.

Melilite

	20	201	Vesuvius, Italy	1

1.—Kaiser, 1899, Zeitschr. f. Kryst., XXXI, p. 24.

Meyerhofferite

a: b: c = 0.7923:1:0.7750 $\alpha = 89° 32'$ $\beta = 79° 19'$ $\gamma = 86° 52'$

c	0	001	Death Valley, Inyo Co., Calif.	1
a	∞0	100	" " " "	1
b	0∞	010	" " " "	1
r	8∞	810	" " " "	1
B	5∞	510	" " " "	1
s	3∞	310	" " " "	1
n	$\frac{5}{2}$∞	520	" " " "	1
q	2∞	210	" " " "	1
m	∞	110	" " " "	1
j	∞$\frac{5}{4}$	450	" " " "	1

A	$\infty\frac{5}{3}$	350	Death Valley, Inyo Co., Calif.				1
l	$\infty 2$	120	"	"	"	"	1
k	$\infty\frac{7}{3}$	370	"	"	"	"	1
h	-3∞	$\bar{3}10$	"	"	"	"	1
w	$-\frac{4}{3}\infty$	$\bar{4}30$	"	"	"	"	1
M	$-\infty$	$\bar{1}10$	"	"	"	"	1
v	$-\infty\frac{5}{3}$	$\bar{3}50$	"	"	"	"	1
t	10	101	"	"	"	"	1
d	$\frac{1}{11}0$	12.0.11	"	"	"	"	1
e	$\frac{7}{6}0$	706	"	"	"	"	1
f	$\frac{6}{5}0$	605	"	"	"	"	1
g	$\frac{5}{4}0$	504	"	"	"	"	1
i	$\frac{7}{5}0$	705	"	"	"	"	1
x	$\frac{3}{2}0$	302	"	"	"	"	1
z	120	12.0.1	"	"	"	"	1
y	-10	$\bar{1}01$	"	"	"	"	1
p	1	111	"	"	"	"	1

1.—W. T. Schaller, 1916, U. S. Geol. Surv., Bull. DCX, p. 41.

Miargyrite

T	$-\frac{1}{6}0$	$\bar{1}06$	Zacatecas, Mexico		1
W	$\frac{1}{12}0$	1.0.12	"	"	1
V	$-\frac{1}{12}0$	$\bar{1}.0.12$	"	"	1
U	$-\frac{1}{30}0$	$\bar{1}.0.30$	"	"	1
K	$\frac{1}{2}$	112	"	"	1
τ	$-1\frac{1}{8}$	$\bar{8}18$	Braunsdorf		2
Γ	$\frac{1}{3}1$	133	Přibram, Bohemia		2
j	$\frac{5}{3}1$	533	"	"	2
Y	$\frac{11}{5}1$	11.5.5	"	"	2
Q	$\frac{7}{3}1$	733	"	"	2
Θ	$-\frac{5}{2}1$	$\bar{5}22$?	"	"	2
H	41	411	Zacatecas, Mexico		1
P	$\frac{15}{2}1$	15.2.2	"	"	1
Ω	$\frac{2}{5}\frac{3}{5}$	235?	Felsöbánya, Hungary		2
Φ	$-\frac{1}{3}\frac{1}{9}$	$\bar{3}19$	Braunsdorf		2
Z	$-3\frac{1}{3}$	$\bar{9}13$	Zacatecas, Mexico		1

1.—A. S. Eakle, 1899, Zeitschr. f. Kryst., XXXI, p. 209.
*2.—V. Rosicky, 1912, Abh. d. böhm. Akad., No. 1, p. 50.

Miersite

Isometric Tetrahedral

o	1	111	Broken Hill, N. S. Wales			1
o_1	—1	$\bar{1}11$	"	"	"	1

1.—L. J. Spencer, 1898, Nature, XLVII, p. 574.

Millerite

a: c = 1:0.3274

d	$\frac{7}{2}\infty$	$72\bar{9}0$	Orford, Quebec, Can.			1
f	$\frac{9}{4}\infty$	$9.4.\bar{1}3.0$?	"	"	"	1
g	$\frac{31}{13}\infty$	$31.13.\bar{4}4.0$?	"	"	"	1
p	02	$02\bar{2}1$	"	"	"	1
l	09	$90\bar{9}1$?	"	"	"	1
m	0.18	$0.18.\bar{1}8.1$?	"	"	"	1
h	30	$30\bar{3}1$?	"	"	"	1
x	40	$40\bar{4}1$?	"	"	"	1
j	50	$50\bar{5}1$?	"	"	"	1
s	21	$21\bar{3}1$	"	"	"	1
u	$-\frac{4}{3}\frac{1}{3}$	$14\bar{5}3$	"	"	"	1
o	$\frac{7}{9}\frac{4}{9}$	$7.4.\bar{1}1.9$?	"	"	"	1
q	$\frac{3}{2}\frac{1}{2}$	$61\bar{7}4$?	"	"	"	1
n	$\frac{5}{6}\frac{1}{3}$	$52\bar{7}6$?	"	"	"	1
w	$\frac{4}{5}\frac{2}{5}$	$42\bar{6}5$?	"	"	"	1

1.—C. Palache and H. O. Wood, 1904, Amer. Journ. Sci., XVIII, p. 343.

Mimetite

a: c = 1:0.7275

α	$\frac{3}{2}0$	$30\bar{3}2$	Tintic Dist., Utah			1
z	30	$30\bar{3}1$	"	"	"	1

1.—E. T. Wherry, 1918, Proc. U. S. Nat. Mus., LIV, p. 373.

Molybdenite

a: c = 1:1.9077

c	0	0001	Frankfort, Pa.			1
m	$\infty 0$	$10\bar{1}0$	"	"		1
q	30	$30\bar{3}1$	"	"		1
p	20	$20\bar{2}1$	"	"		1
r	$\frac{5}{4}0$	$50\bar{5}4$	Kingston, Ont., Can.			2
o	10	$10\bar{1}1$	Frankfort, Pa.			1

t	$\frac{2}{3}0$	$20\bar{2}3$	Warren, N. H.	2
s	$\frac{2}{5}0$	$20\bar{2}5$	Kingston, Ont., Can.	2
u	$\frac{1}{4}0$	$10\bar{1}4$	Okanogan Co., Wash.	2

1.—A. P. Brown, 1896, Proc. Acad. Nat. Sci. Phila., p. 210.
2.—A. J. Moses, 1904, Amer. Journ. Sci., XVII, p. 359.

Monazite

g	$\infty\frac{3}{2}$	230		3
μ	$\infty 3$	130	Tintagel, Cornwall	1
ρ	$-\frac{1}{3}0$	$\bar{1}03$	Trundle, (Condobolin), N. S. Wales	2
	$-\frac{3}{2}0$	$\bar{3}02$?	King's Bluff, Olary, S. Australia	2
σ	-30	$\bar{3}01$	California Creek, Queensland	2
	$-\frac{1}{2}$	$\bar{1}12$		4
	$-\frac{1}{3}$	$\bar{1}13$		4
λ	$1\frac{1}{2}$	212	King's Bluff, Olary, S. Australia	2
	$\frac{1}{2}1$	122		4
Θ	$-\frac{1}{2}1$	$\bar{1}22$	Tintagel, Cornwall	1
η	$-\frac{1}{2}\frac{3}{2}$	$\bar{1}32$	" "	1

1.—A. S. Bowman, 1900, Min. Mag., XII, p. 349.
2.—C. Anderson, 1909, Rec. Austr. Mus., VII, p. 280; 1910, idem, VIII, p. 128.
3.—J. Scheielig, 1913, Norsk. Geol. Tidskrift, II, (III), p. 38.
4.—H. Ungemach, 1916, Bull. Soc. fr. Min., XXXIX.

Montroydite

a: b: c = 0.6375:1:1.1977

a	$\infty 0$	100	Terlingua, Texas	1
b	0∞	010	" "	1
Φ	5∞	510	" "	2
j	4∞	410	" "	2
ξ	3∞	310	" "	2
f	$\frac{3}{2}\infty$	320	" "	2
m	∞	110	" "	1
C	$\infty\frac{3}{2}$	230	" "	2
k	$\infty\frac{5}{3}$	350	" "	2
h	$\infty 2$	120	" "	2
l	$\infty 10$	1.10.0	" "	2
v	$0\frac{1}{2}$	012	" "	2
y	$0\frac{2}{3}$	023	" "	2
K	$0\frac{4}{5}$	045	" "	2
z	01	011	" "	2
G	$0\frac{3}{2}$	032	" "	2
L	02	021	" "	2

β	06	061	Terlingua, Texas		2
E	$\frac{1}{3}0$	103	"	"	2
g	$\frac{1}{2}0$	102	"	"	2
M	$\frac{2}{3}0$	203	"	"	2
d	10	101	"	"	1
n	$\frac{3}{2}0$	302	"	"	2
q	20	201	"	"	2
μ	30	301	"	"	2
A	$\frac{1}{4}$	114	"	"	2
B	$\frac{1}{3}$	113	"	"	2
S	$\frac{1}{2}$	112	"	"	1
D	$\frac{2}{3}$	223	"	"	2
o	1	111	"	"	1
i	2	221	"	"	2
x	3	331	"	"	1
δ	5	551	"	"	2
s	$1\frac{3}{2}$	232	"	"	2
Δ	$1\frac{1}{3}$	313	"	"	2
α	$\frac{1}{3}1$	133	"	"	2
t	$\frac{1}{2}1$	122	"	"	1
π	$1\frac{2}{3}$	323	"	"	2
U	$\frac{3}{4}1$	344	"	"	2
r	21	211	"	"	1
w	31	311	"	"	1
W	41	411	"	"	2
O	$\frac{2}{3}\ \frac{4}{3}$	243	"	"	2
ξ	$\frac{2}{5}\ \frac{6}{5}$	265	"	"	2
e	$\frac{1}{2}\ \frac{3}{2}$	132	"	"	1
N	$\frac{2}{3}3$	263	"	"	2
Z	$\frac{1}{2}\ \frac{7}{6}$	176	"	"	2
Q	$\frac{2}{9}\ \frac{1}{3}$	239	"	"	2
V	$\frac{1}{2}\ \frac{2}{5}$	5.4.10	"	"	2
γ	$\frac{5}{2}2$	542	"	"	2
P	$\frac{1}{2}\ \frac{1}{3}$	326	"	"	2
φ	$3\frac{3}{2}$	632	"	"	2
λ	$\frac{3}{7}\ \frac{1}{7}$	317	"	"	2
ρ	$\frac{7}{13}\ \frac{3}{13}$	7.3.13	"	"	2
ω	$\frac{5}{6}\ \frac{1}{12}$	10.1.12	"	"	2

1.—A. J. Moses, 1903, Amer. Journ. Sci., XVI, p. 253.

*2.—W. F. Hillebrand and W. T. Schaller, 1909, U. S. Geol. Surv., Bull. XLVII, p. 405.

Mosesite

Isometric

$\infty 0$	100	Terlingua, Texas	2
1	111	" "	1
$\frac{1}{2}$	112	" "	2
$\frac{1}{4}$	114	" "	2
$\frac{1}{6}$	116	" "	2

1.—F. A. Canfield, W. F. Hillebrand and W. T. Schaller, 1910, Amer. Journ. Sci., XXX, p. 202.
2.—F. A. Canfield, 1913, School of Mines Quar., XXXIV, p. 276.

Mossite

Tetragonal · $a:c=1:0.6438$

c	0∞	001	Moss, Norway	1
a	$\infty 0$	100	" "	1
m	∞	110	" "	1
y	$\frac{3}{5}0$	305	" "	1
	10	101	" "	1
v	30	301	" "	1
o	1	111	" "	1
φ	$\frac{3}{5}\ \frac{9}{10}$	6.9.10	" "	1

1.—W. C. Brögger, 1897, Vidensk. Skrift., Math.-Nat. Klasse, No. 7.

Muscovite

o	—1	$\bar{1}11$	Mitchell Co., N. C.		1
ϵ	$-\frac{4}{7}$	$\bar{4}47$	"	"	" 1
e	—3	$\bar{3}31$	"	"	" 1
v	—5	$\bar{5}51$	"	"	" 1
τ	$\frac{10}{3}$	10.10.3	"	"	" 1
	$\frac{29}{30}$	29.29.30	"	"	" 1
Θ	$-\frac{11}{3}$	$\bar{11}.11.3$	"	"	" 1
η	$-\frac{23}{6}$	$\bar{23}.23.6$	"	"	" 1

1.—H. Baumhauer, 1899, Zeitschr. f. Kryst., XXXII, p. 164.

Narsarsukite

Tetragonal $a:c=1:0.52352$

c	0	001	Narsarsuk, Greenland	1
a	$\infty 0$	100	" "	1
n	2∞	210	" "	1

m	∞	110	Narsarsuk, Greenland	1
p	1	111	" "	1

1.—G. Flink, 1898, Medd. om Grönland, XIV, p. 234.

Nasonite

Hexagonal $a:c=1:1.3167$

m	∞0	$10\bar{1}0$	Franklin Furnace, N. J.		1
a	∞	$11\bar{2}0$	"	" "	1
p	10	$10\bar{1}1$	"	" "	1
x	$\frac{9}{2}0$	$90\bar{9}2$	"	" "	1

1.—C. Palache, 1910, Amer. Journ. Sci., XXIX, p. 181.

Natrochalcite

$a:b:c=1.423:1:1.214 \quad \beta=61°\ 17'$

c	0	001	Chuquicamata, Chile		1
b	0∞	010	"	"	1
m	∞	110	"	"	1
p	1	111	"	"	1
q	—1	$\bar{1}11$	"	"	1
v	$\frac{1}{2}$	112	"	"	1
u	2	221	"	"	1
w	3	331	"	"	1
x	—2	$\bar{2}21$	"	"	1

1.—C. Palache and C. H. Warren, 1908, Amer. Journ. Sci., XXIV, p. 345.

Natro-davyne

Hexagonal $a:c=1:0.8360$

c	0	0001	Vesuvius, Italy		1
m	∞0	$10\bar{1}0$	"	"	1
d	3∞	$31\bar{4}0$	"	"	1
n	2∞	$21\bar{3}0$	"	"	1
a	∞	$11\bar{2}0$	"	"	1
g	$\frac{2}{5}0$	$20\bar{2}5$	"	"	1
q	$\frac{1}{2}0$	$10\bar{1}2$	"	"	1
u	$\frac{4}{7}0$	$40\bar{4}7$	"	"	1
t	$\frac{2}{3}0$	$20\bar{2}3$	"	"	1
p	10	$10\bar{1}1$	"	"	1
f	$\frac{4}{3}0$	$40\bar{4}3$	"	"	1
z	20	$20\bar{2}1$	"	"	1
v	30	$30\bar{3}1$	"	"	1

i	$\frac{10}{3}0$	10.0.$\bar{1}\bar{0}$.3	Vesuvius, Italy	1
x	40	40$\bar{4}$1	" "	1
y	60	60$\bar{6}$1	" "	1
l	80	80$\bar{8}$1	" "	1
r	10.0	10.0.$\bar{1}\bar{0}$.1	" "	1
s	1	11$\bar{2}$1	" "	1

1.—F. Zambonini, 1910, Mem. R. Accad. d. Sc. Napoli, XIV, p. 188.

Natrojarosite

Hexagonal Rhombohedral *a: c* = 1:1.104

c	0	0001	Esmeralda Co., Nev.	1
r	10	10$\bar{1}$1	" " "	1
s	—20	02$\bar{2}$1	" " "	1

1.—W. F. Hillebrand and S. L. Penfield, 1905, Zeitschr. f. Kryst., XXXVI, p. 546.

Natrolite

j	$\frac{1}{2}$	112	Langesundfjord, Norway	1
k	$\frac{3}{5}$	335	" "	1
g	$\frac{3}{4}$	334	" "	1
ξ	$\frac{16}{17}$	16.16.17	" "	1
α	$1\frac{3}{5}$	535	San Benito Co., Calif.	2
p	36	361	Langesundfjord, Norway	1
ϵ	$\frac{4}{3}$ $\frac{1}{2}$	836	" "	1

1.—F. Zambonini, 1901, Zeitschr. f. Kryst., XXXIV, p. 549.
2.—B. Ježek, 1909, Abh. d. böhm. Akad.

Nephelite

	51	5161	Vesuvius, Italy	1

1.—E. Kaiser, 1899, Zeitschr. f. Kryst., XXXI, p. 28.

Neptunite

a: b: c = 1.3164:1:0.8076 β = 64° 22′

c	0	001	Narsarsuk, Greenland	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
m	∞	110	" "	1
f	—10	$\bar{1}$01	Julianehaab, "	2
e	—20	$\bar{2}$01	Narsarsuk, "	1
d	—30	$\bar{3}$01	" "	1
s	1	111	" "	1

h	$\frac{8}{7}$	887	San Benito Co., Calif.	6
r	2	221	Julianehaab, Greenland	2
i	$-\frac{1}{2}$	$\bar{1}12$	" "	2
o	—1	$\bar{1}11$	Narsarsuk, "	1
r	—2	$\bar{2}21$	Julianehaab, "	2
x	31	311	" "	2
p	—31	$\bar{3}11$	" "	3
γ	$-\frac{5}{2}1$	$\bar{5}22$	San Benito Co., Calif.	5
g	—21	$\bar{2}11$	" " "	4
u	$-\frac{5}{2}\ \frac{1}{2}$	$\bar{5}12$	Narsarsuk, Greenland	1
q	$-\frac{7}{2}\ \frac{1}{2}$	$\bar{7}12$	Julianehaab, "	3

1.—G. Flink, 1893, Geol. Fören. Förh., XV, p. 196.
2.—G. Flink, 1898, Medd. om Grönland, XIV, p. 232.
3.—A. Wallenstrom. 1905, Geol. Fören. Förh., XXVII, p. 149.
4.—W. E. Ford, 1909, Amer. Journ. Sci., XXVII, p. 235.
5.—C. Hlawatach, 1909, Min. Mitth., XXVIII, p. 293.
*6.—W. T. Schaller, 1911, Zeitschr. f. Kryst., XLVII, p. 556.

Niccolite

a: c = 1:0.9508

a	∞	$11\bar{2}0$	Mansfield, Saxony, Ger.	1
n	∞7	$17\bar{8}0$	Riechelsdorf, Hesse, "	2
π	$\frac{1}{5}0$	$10\bar{1}5$	Mansfield, Saxony, "	1
w	$\frac{3}{5}0$	$30\bar{3}5$	" " "	1
x	$\frac{3}{4}0$	$30\bar{3}4$	Riechelsdorf, Hesse, "	2
o	$\frac{5}{3}0$	$50\bar{5}3$	Mansfield, Saxony, "	1
z	$\frac{1}{1}\frac{7}{0}0$	$17.0.\bar{1}7.10$	" " "	1
s	$\frac{9}{5}0$	$90\bar{9}5$	" " "	1
l	20	$20\bar{2}1$	Artificial	3
α	$\frac{2}{1}\frac{3}{0}0$	$23.0.\bar{2}3.10$	Mansfield, Saxony, Ger.	1
q	$\frac{1}{5}\frac{2}{}0$	$12.0.\bar{1}2.5$	" " "	1
f	$\frac{8}{3}0$	$80\bar{8}3$	Artificial	3
u	30	$30\bar{3}1$	Mansfield, Saxony, Ger.	1
t	$\frac{1}{5}\frac{6}{}0$	$16.0.\bar{1}6.5$	" " "	1
v	40	$40\bar{4}1$	" " "	1
γ	$\frac{2}{5}\frac{2}{}0$	$22.0.\bar{2}2.5$	" " "	1
y	$\frac{9}{2}0$	$90\bar{9}2$	Riechelsdorf, Hesse, Ger.	2
v	$-\frac{9}{2}0$	$09\bar{9}2$	" " "	2
s	$-\frac{3}{2}0$	$03\bar{3}2$	" " "	2
ξ	$-\frac{3}{4}0$	$03\bar{3}4$	" " "	2

1.—A. Sachs, 1902, Sitz. Ber. Akad., p. 856.
2.—V. Dürrfeld, 1911, Zeitschr. f. Kryst., XLIX, p. 477.
3.—A. Rosati, 1913, Rend. Accad. Linc., (5) XXII, (II), p. 243.

Northupite

Isometric

o	1	111	Borax Lake, San Bernardino Co., Calif.	1

1.—W. M. Foote, 1895, Amer. Journ. Sci., L, p. 480.

Octahedrite

G	$\frac{1}{4}0$	104		7
R	$\frac{3}{10}0$	3.0.10	Binnenthal, Switzerland	6
	$\frac{1}{2}0$	102	Unknown Locality	15
E	$\frac{2}{3}0$	203?	Binnenthal, Switzerland	6
	$\frac{5}{43}$	5.5.43	" "	8
	$\frac{5}{29}$	5.5.29	" "	8
	$\frac{2}{11}$	2.2.11	Pregratten, "	3
Δ	$\frac{2}{9}$	229	Binnenthal, "	13
M	$\frac{3}{8}$	338	Binnenthal, Switzerland and Jequilinhuaha Riv., Brazil	10+11
	$\frac{4}{9}$	449	Mt. St. Vincent, Brabant, Belgium	9
T	$\frac{7}{13}$	7.7.13		14
	$\frac{9}{10}$	9.9.10	Votawa, Pisek, Bohemia	2
U	$\frac{7}{6}$	776		14
Φ	$\frac{4}{3}$	443	Binnenthal, Switzerland	13
	$\frac{5}{3}$	553	" "	5
H	$\frac{3}{2}$	332	" "	6
	$\frac{11}{3}$	11.11.3	" "	4
	5	551	" "	4
S	$\frac{13}{2}$	13.13.2		14
W	$\frac{19}{2}$	19.19.2		14
	$\frac{1}{3}\frac{1}{6}$	216	Unknown Locality	15
σ	$\frac{1}{5}\frac{1}{10}$	2.1.10	Pregratten, Switzerland	3
s	$\frac{5}{19}\frac{1}{19}$	5.1.19	" "	3
T	$\frac{1}{12}\frac{1}{6}$	11.2.12	Binnenthal, "	6
L	$5\frac{1}{5}$	25.11.5	" "	6
	$\frac{1}{3}\frac{1}{10}$	10.3.30	Beaume, Oulix, Piedmont, Italy	12
σ	$\frac{1}{4}\frac{3}{44}$	11.3.44?	Bourg d'Oisans, Isère, France	1
	$\frac{9}{10}\frac{18}{25}$	45.36.50	Binnenthal, Switzerland	8

$\frac{9}{2}\,\frac{3}{14}$	63.3.14	Binnenthal, Switzerland		8
$9\frac{3}{20}$	180.3.20	"	"	8
$7\frac{3}{5}$	35.3.5	"	"	5
$8\frac{3}{5}$	40.3.5	"	"	5
$\frac{24}{7}2$	24.14.7	"	"	5

1.—K. Busz, 1892, Zeitschr. f. Kryst., XX, p. 529.
2.—Krejci, 1904, Abh. d. böhm. Akad., No. 3, p. 13.
3.—O. Pohl, 1902, Min. u. petro. Mitth., XXII, p. 473.
4.—H. Baumhauer, 1903, Centralb. f. Min., p. 672.
5.—R. W. Solly, 1904, Min. Mag., XIV, p. 16.
6.—F. Millosevich, 1905, Rend. Accad. Linc., XIV, p. 92.
7.—C. Hintze, 1906, Handbuch Min., I, p. 1563.
8.—R. W. Harre, 1906, Zeitschr. f. Kryst., XLII, p. 280.
9.—W. Prinz, 1907, Bull. Ac. Belg., p. 706.
10.—G. Cesàro, 1907, Bull. Ac. Belg., p. 336.
11.—O. C. Farrington and E. W. Tillotson, 1908, Field Col. Mus. (Geol.), III, No. 7, p. 150.
12.—L. Colomba, 1909, Riv. Min. Ital., XXXVIII, p. 50.
13.—N. Henglein, 1909, Verh. d. Ver. Heidelberg, N. F., X, p. 48.
14.—J. Schetelig, 1913, Norsk. Geol. Tidsskrift, II (III), p. 38.
15.—H. Buttgenbach, 1913, Bull. Soc. Géol. Belg., XL, p. 378.

Olivenite

d	$0\frac{2}{5}$	025	Tintic Dist., Utah	1
s	$0\frac{3}{4}$	034	" " "	1

1.—O. C. Farrington and E. W. Tillotson, 1908, Field Col. Mus. (Geol.), III, p. 152.

Orpiment

a: b: c = 0.5962:1:0.6650 $\beta = 90°\ 41'$

a	$\infty 0$	100	Alchar, Macedonia	1
b	0∞	010	" "	1
s	$\frac{3}{2}\infty$	320	" "	1
m	∞	110	" "	1
u	$\infty 2$	120	" "	1
g	$\infty 3$	130	" "	1
h	$\infty 6$	160	" "	1
l	$0\frac{2}{3}$	023	Mercur, Utah	2
	$\frac{1}{3}0$	103	Alchar, Macedonia	1
o	10	101	" "	1
d	$-\frac{1}{3}0$	$\bar{1}03$	Mercur, Utah	2
q	$-\frac{4}{9}$	$\bar{4}49$	Alchar, Macedonia	1
x	$-1\frac{2}{3}$	$\bar{3}23$	" "	1

v	$-1\frac{4}{3}$	$\bar{3}43$	Alchar, Macedonia	1
β	$-1\frac{3}{2}$	$\bar{2}32$	" "	1
y	$-1\frac{8}{5}$	$\bar{5}85$	" "	1
f	$-1\frac{5}{2}$	$\bar{2}52$	" "	1
v	-12	$\bar{1}21$	" "	1
n	$-\frac{1}{3}1$	$\bar{1}33$	Mercur, Utah	2
	$\frac{1}{3}\ \frac{4}{3}$	143	Alchar, Macedonia	1
i	$\frac{2}{3}\ \frac{4}{3}$	243	" "	1
Q	$\frac{1}{3}\ \frac{1}{2}$	236	" "	1
z	$\frac{5}{3}\ \frac{2}{3}$	523	" "	1
k	$-\frac{1}{3}\ \frac{2}{3}$	$\bar{1}23$	" "	1
t	$-7\frac{2\ 0}{3}$	$\bar{2}\bar{1}.20.3$	" "	1
χ	$-\frac{4}{3}\ \frac{2}{3}$	$\bar{4}23$	" "	1

1.—S. Stephanović, 1904, Zeitschr. f. Kryst., XXXIX, p. 14.
2.—O. C. Farrington and E. W. Tillotson, 1908, Field Col. Mus. (Geol.), III, p. 154.

Orthoclase

	3∞	310	Elba, Italy	2
ζ	2∞	210	Schwartzenstein, Tyrol	1
	$\frac{7}{4}\infty$	740	Elba, Italy	2
	$\infty\frac{2\ 0}{7}$	7.20.0	" "	2
ω	$0\frac{1}{7}$	017	Schwartzenstein, Tyrol	1
	$-\frac{5}{6}0$	$\bar{5}06$	Elba, Italy	2
	$-\frac{1\ 4}{1\ 5}0$	$\bar{1}\bar{4}.0.15$	" "	2
χ	$-\frac{3\ 9}{3\ 8}0$	$\bar{3}\bar{9}.0.38$	Schwartzenstein, Tyrol	1
	$-\frac{1\ 3}{1\ 2}0$	$\bar{1}\bar{3}.0.12$	Elba, Italy	2
	$-\frac{1\ 6}{1\ 3}0$	$\bar{1}\bar{6}.0.13$	" "	2
	-12.0	$\bar{1}\bar{2}.0.1$	" "	2
a_x	3	331	Montalban, Nice, France	3
	$-\frac{5}{1\ 1}$	$\bar{5}.5.11$	Elba, Italy	2
	$-\frac{1\ 4}{1\ 5}$	$\bar{1}\bar{4}.14.15$	" "	2
	$-1\frac{3}{7}$	$\bar{7}37$	" "	2
b_y	$\frac{3}{2}\ \frac{9}{2}$	392	Montalban, Nice, France	3
	$-\frac{1\ 1}{1\ 0}\ \frac{1}{1\ 0}$	$\bar{1}\bar{1}.1.10$	Elba, Italy	2
	-97	$\bar{9}71$	" "	2

1.—A. Cathrein, 1888, Min. u. petro. Mitth., X, p. 524.
2.—G. Bartalini, 1901, Acc. Soc. Med. Ferrara.
3.—A. Rosati, 1915, Rend. Accad. Linc., XXIV, p. 39.

Parahopeite

$a:b:c = 0.7729:1:0.7124$ $\alpha = 93°\ 22'$ $\beta = 91°\ 12'$ $\gamma = 91°\ 22'$

0	001	Broken Hill, Rhodesia, Africa				1
$\infty 0$	100	"	"	"	"	1
0∞	010	"	"	"	"	1
3∞	310	"	"	"	"	1
∞	110	"	"	"	"	1
$\infty 2$	120	"	"	"	"	1
$\infty 6$	160	"	"	"	"	1
$-\infty$	$1\bar{1}0$	"	"	"	"	1
$-\infty 2$	$1\bar{2}0$	"	"	"	"	1
$-\infty 6$	$1\bar{6}0$	"	"	"	"	1
02	021	"	"	"	"	1
01	011	"	"	"	"	1
$0\frac{2}{3}$	023	"	"	"	"	1
-01	$0\bar{1}1$	"	"	"	"	1
$-0\frac{1}{2}$	$0\bar{1}2$	"	"	"	"	1
$\frac{2}{3}0$	203	"	"	"	"	1
1	111	"	"	"	"	1
$1\bar{1}$	$1\bar{1}1$	"	"	"	"	1
$\bar{1}1$	$\bar{1}11$	"	"	"	"	1
$\bar{1}$	$\bar{1}\bar{1}1$	"	"	"	"	1
$\frac{1}{2}\frac{1}{2}$	$1\bar{1}2$	"	"	"	"	1
13	131	"	"	"	"	1
$\bar{1}3$	$\bar{1}31$	"	"	"	"	1
$1\bar{2}$	$1\bar{2}1$	"	"	"	"	1
$\bar{1}2$	$\bar{1}21$	"	"	"	"	1
$\frac{3}{2}1$	322	"	"	"	"	1
23	231	"	"	"	"	1
$\frac{4}{3}\frac{2}{3}$	423	"	"	"	"	1
$\frac{5}{2}\frac{1}{2}$	$5\bar{1}2$	"	"	"	"	1
$\frac{1}{3}\frac{4}{3}$	$1\bar{4}3$	"	"	"	"	1
$\frac{1}{2}\bar{3}$	$1\bar{6}2$	"	"	"	"	1
$\bar{2}7$	$\bar{2}71$	"	"	"	"	1

1.—A. Ledoux, T. L. Walker, and A. C. Wheatley, 1917, Min. Mag., XVIII, p. 101.

Paralaurionite

$a:b:c = 2.7036:1:1.8019$ $\beta = 62°\ 47'$

c	0	001	Laurium, Greece			1
a	$\infty 0$	100	"	"		1

	0∞	010	Sierra Gorda, Chile [Rafaelite (010)]	2
m	∞	110	Laurium, Greece	1
	40	410	Sierra Gorda, Chile [Rafaelite (201)]	2
	20	210	" " " [" (101)]	2
d	10	101	Laurium, Greece	1
	$-\frac{2}{3}0$	$\bar{2}03$	Sierra Gorda, Chile [Rafaelite ($\bar{1}03$)]	2
h	—20	$\bar{2}01$	Laurium, Greece	1
k	—40	$\bar{4}01$	" "	1
l	—60	$\bar{6}01$	" "	1
p	1	111	" "	1
	41	411	Sierra Gorda, Chile [Rafaelite (432)]	2

1.—G. F. Herbert-Smith, 1899, Min. Mag., XII, pp. 108, 183.
2.—A. Arzruni, 1899, Zeitschr. f. Kryst., XXXI, p. 229.

Paratacamite

Hexagonal Rhombohedral $a:c = 1:1.0248$

c	0	0001	Sierra Gorda, San Cristobal, Chile				1
a	∞	$11\bar{2}0$	"	"	"	"	"	1
ω	$\frac{2}{5}0$	$20\bar{2}5$	"	"	"	"	"	1
w	$\frac{4}{7}0$	$40\bar{4}7$	"	"	"	"	"	1
v	$\frac{7}{13}0$	$\bar{7}.0.\bar{7}.13$	"	"	"	"	"	1
r	10	$10\bar{1}1$	"	"	"	"	"	1
e	$-\frac{1}{2}0$	$01\bar{1}2$	"	"	"	"	"	1
f	—20	$02\bar{2}1$	"	"	"	"	"	1
l	24	$24\bar{6}1$	"	"	"	"	"	1

1.—G. F. Herbert-Smith, 1906, Min. Mag., XIV, p. 120.

Parisite

Hexagonal Rhombohedral $a:c = 1:1.9363$

b	$\frac{4}{15}$	$4.4.\bar{8}.15$	Quincy, Mass.		3
i	$\frac{1}{3}$	$11\bar{2}3$	"	"	3
l	$\frac{11}{27}$	$11.11.\bar{2}\bar{2}.27$	"	"	3
n	$\frac{5}{12}$	$5.5.\bar{1}0.12$	"	"	3
t	$\frac{4}{9}$	$44\bar{8}9$	"	"	3
u	$\frac{5}{9}$	$5.5.\bar{1}0.9$	"	"	3
r	$\frac{2}{3}$	$22\bar{4}3$	Narsarsuk, Greenland		1
	$\frac{5}{6}$	$5.5.\bar{1}0.6$	Muso, Colombia, S. America		2
s	$\frac{4}{3}$	$44\bar{8}3$	Narsarsuk, Greenland		1
	$\frac{5}{3}$	$5.5.\bar{1}0.3$	Muso, Colombia, S. America		2
A	$\frac{1}{4}0$	$10\bar{1}4$	Quincy, Mass.		3

B	$\frac{4}{1\,5}0$	$4.0.\bar{4}.15$	Quincy, Mass.		3
C	$\frac{3}{1\,1}0$	$3.0.\bar{3}.11$	"	"	3
D	$\frac{3}{1\,0}0$	$3.0.\bar{3}.10$	"	"	3
E	$\frac{5}{1\,6}0$	$5.0.\bar{5}.16$	"	"	3
F	$\frac{1}{3}0$	$10\bar{1}3$	"	"	3
G	$\frac{5}{1\,3}0$	$5.0.\bar{5}.13$	"	"	3
H	$\frac{2}{5}0$	$20\bar{2}5$	"	"	3
i	$\frac{8}{1\,1}0$	$8.0.\bar{8}.11$	"	"	3
J	$\frac{7}{8}0$	$70\bar{7}8$	"	"	3
	$\frac{6}{5}0$	$60\bar{6}5$			4
L	$\frac{5}{4}0$	$50\bar{5}4$	Quincy, Mass.		3
M	$\frac{4}{3}0$	$40\bar{4}3$	"	"	3
N	$\frac{1\,1}{6}0$	$11.0.\bar{11}.6$	"	"	3
P	$\frac{1\,1}{4}0$	$11.0.\bar{11}.4$	"	"	3
Q	$\frac{1\,0}{3}0$	$10.0.\bar{10}.3$	"	"	3
R	40	$40\bar{4}1$	"	"	3
T	50	$50\bar{5}1$	"	"	3
V	60	$60\bar{6}1$	"	"	3
β	$-\frac{4}{1\,5}0$	$0.4.\bar{4}.15$	"	"	3
γ	$-\frac{2}{7}0$	$02\bar{2}7$	"	"	3
δ	$-\frac{3}{1\,0}0$	$0.3.\bar{3}.10$	"	"	3
ϵ	$-\frac{9}{2\,5}0$	$0.9.\bar{9}.25$	"	"	3
ζ	$-\frac{1}{2}0$	$01\bar{1}2$	"	"	3
Θ	$-\frac{5}{8}0$	$05\bar{5}8$	"	"	3
η	$-\frac{6}{5}0$	$06\bar{6}5$	Muso, Colombia, S. America		2
λ	$-\frac{5}{4}0$	$05\bar{5}4$	Quincy, Mass.		3
h	$-\frac{3}{2}0$	$03\bar{3}2$	Muso, Colombia, S. America		2
μ	-20	$02\bar{2}1$	"	" "	2
π	$-\frac{5}{2}0$	$05\bar{5}2$	"	" "	3
σ	-30	$03\bar{3}1$	"	" "	3
φ	$-\frac{7}{2}0$	$07\bar{7}2$	"	" "	3
ρ	-40	$04\bar{4}1$	"	" "	3
ψ	-50	$05\bar{5}1$	"	" "	3
ω	-60	$06\bar{6}1$	"	" "	3
	-80	$08\bar{8}1$			4
y	$\frac{4}{1\,1}\,\frac{2}{1\,1}$	$4.2.\bar{6}.11$	Quincy, Mass.		3

1.—G. Flink, 1898, Medd. om Grönland, XIV, p. 236.
2.—G. Cesàro, 1907, Bull. Ac. Belg., p. 321.
3.—C. Palache and C. H. Warren, 1911, Amer. Journ. Sci., XXXI, p. 533.
4.—H. Ungemach, 1916, Bull. Soc. fr. Min., p. 39.

Pearceite

$a:b:c = 1.7309:1:1.6199 \quad \beta = 89° 51'$

c	0	001	Marysvale, Mont.		1
a	$\infty 0$	100	"	"	1
b	0∞	010	"	"	1
l	3∞	310	"	"	1
m	∞	110	"	"	1
h	$\infty 3$	130	"	"	1
k	02	021	"	"	1
d	$\frac{1}{2}0$	102	"	"	1
n	10	101	"	"	1
t	20	201	"	"	1
e	40	401	"	"	1
f	60	601	"	"	1
$f°$	—60	$\bar{6}01$	"	"	1
$e°$	—40	$\bar{4}01$	"	"	1
$t°$	—20	$\bar{2}01$	"	"	1
$n°$	—10	$\bar{1}01$	"	"	1
Δ	$-\frac{2}{3}0$	$\bar{2}03$	"	"	1
o	$\frac{1}{4}$	114	"	"	1
r	$\frac{1}{2}$	112	"	"	1
p	1	111	"	"	1
v	$\frac{3}{2}$	332	"	"	1
s	2	221	"	"	1
u	3	331	"	"	1
$u°$	—3	$\bar{3}31$	"	"	1
$s°$	—2	$\bar{2}21$	"	"	1
$v°$	$-\frac{3}{2}$	$\bar{3}32$	"	"	1
$p°$	—1	$\bar{1}11$	"	"	1
$r°$	$-\frac{1}{2}$	$\bar{1}12$	"	"	1
$q°$	$-\frac{1}{3}$	$\bar{1}13$	"	"	1
$o°$	$-\frac{1}{4}$	$\bar{1}14$	"	"	1
y	$1\frac{1}{3}$	313	"	"	1
x	31	311	"	"	1
z	$\frac{1}{4}\ \frac{1}{12}$	3.1.12	"	"	1

1.—S. L. Penfield, 1896, Amer. Journ. Sci., II, p. 17.

Pectolite

h	$\frac{5}{4}\infty$	540	Bergen Hill, N. J.	1
y	$\frac{1}{2}\frac{1}{5}0$	1.0.25	" " "	1
x	$\frac{1}{2}0$	102	" " "	1

1.—A. J. Moses, 1901, Amer. Journ. Sci., XII, p. 99.

Penfieldite

Hexagonal $a:c=1:0.8967$

c	0	0001	Laurium, Greece	1
m	$\infty 0$	$10\bar{1}0$	" "	1
p	$\frac{1}{2}$	$11\bar{2}2$	" "	1

1.—S. L. Penfield, 1894, Amer. Journ. Sci., XLVIII, p. 114.

Phenacite

$a:c=1:0.6611$

d_1	$\frac{1}{2}0$	$10\bar{1}2$	Minas Geraes, Brazil	3
y_1	$-\frac{1}{5}1$	$15\bar{6}5$	East Africa	1
γ	$-\frac{1}{2}\frac{7}{2}$	$17\bar{8}2$	Minas Geraes, Brazil	4
f'	$-\frac{5}{9}\frac{13}{18}$	$10.13.\bar{2}\bar{3}.18$	" " "	2
b	$\frac{3}{4}\frac{1}{2}$	$32\bar{5}4$	" " "	2
b_1	$-\frac{1}{2}\frac{3}{4}$	$23\bar{5}4$	" " "	2
e	$\frac{4}{7}\frac{3}{7}$	$43\bar{7}7$	" " "	2
v_1	$\frac{2}{3}$	$22\bar{4}3r$	" " "	3

1.—L. J. Spencer, 1906, Min. Mag., XIV, p. 178.
2.—K. Zimanyi, 1909, Zeitschr. f. Kryst., XLVII, p. 97.
3.—F. Slavic, 1909, Bull. Ac. Böhm., XIV.
4.—V. Goldschmidt and P. Schröder, 1909, Zeitschr. f. Kryst., XLVI, p. 465.

Phosgenite

ϵ	$\frac{1}{2}0$	102	Monteponi, Sardinia	1
	21	211	San Giovanni, "	2
	$\frac{1}{3}\frac{3}{3}\frac{7}{3}$	13.7.3	" "	2

1.—F. Millosevich, 1909, Rend. Accad. Linc., XVIII, (2) p. 116.
2.—G. Cesàro, 1912, Bull. Acad. Roy. Belg., p. 381.

Piedmontite

m_x	$\frac{1}{2}0$	102	St. Marcel, Piedmont, Italy	1
	$-\frac{1}{7}0$	$\bar{1}07$	" " "	1
l	-20	$\bar{2}01$	" " "	1

1.—F. Zambonini. 1902, Zeitschr. f. Kryst., XXXVIII, p. 15.

Pisanite

a	$\infty 0$	100	Leona Heights, Almeda Co., Calif.	1
h	2∞	210	" " " "	1
f	$\frac{3}{2}\infty$	320	" " " "	1
l	$\infty 2$	120	" " " "	1
v	10	101	" " " "	1
r	1	111	" " " "	1
E	$-\frac{2}{3}$	$\bar{2}23$	" " " "	1
D	-2	$\bar{2}21$	" " " "	1
σ	-12	$\bar{1}21$	" " " "	1

1.—W. T. Schaller, 1903, Bull. Univ. Calif. (Geol), III, p. 199.

Pirssonite

$a:b:c = 0.5662:1:0.3019$

b	0∞	010	Borax Lake, San Bernardino Co., Calif.	1
m	∞	110	Borax Lake, San Bernardino Co., Calif.	1
p	1	111	Borax Lake, San Bernardino Co., Calif.	1
p_1	-1	$11\bar{1}$	Borax Lake, San Bernardino Co., Calif.	1
e	13	131	Borax Lake, San Bernardino Co., Calif.	1
x	31	311	Borax Lake, San Bernardino Co., Calif.	1

1.—J. H. Pratt, 1896, Amer. Journ. Sci., II, p. 126.

Plagionite

$a:b:c = 1.1305:1:0.8422 \quad \beta = 107° 15'$

b	0∞	010	Wolfsberg, Harz Germany	1
γ	3∞	310	Oruro, Bolivia	2
m	∞	110	Wolfsberg, Harz, Germany	1
ξ	$0\frac{2}{3}$	023	Oruro, Bolivia	2
ζ	$0\frac{4}{5}$	045	" "	2
Ω	01	011	" "	2
η	$0\frac{4}{3}$	043	" "	2
u	10	101	" "	2
f	-10	$\bar{1}01$	Wolfsberg, Harz, Germany	1

g	—20	$\bar{2}01$	Wolfsberg, Harz, Germany	1
	—$\frac{7}{3}$0	$\bar{7}03$?	" " "	1
	—70	$\bar{7}01$?	" " "	1
L	$\frac{1}{3}$	113	Oruro, Bolivia	2
L_1	$\frac{4}{11}$	4.4.11	Wolfsberg, Harz, Germany	1
l	$\frac{2}{3}$	$\bar{2}23$	" " "	1
	—$\frac{1}{4}$	$\bar{1}14$	" " "	1
	—$\frac{2}{5}$	$\bar{2}25$	" " "	1
t	—$\frac{4}{5}$	$\bar{4}45$	" " "	1
k	—1	$\bar{1}11$	" " "	1
N	—$\frac{4}{3}$	$\bar{4}43$	Oruro, Bolivia	2
S	10.1	10.1.1	" "	2
σ	—31	$\bar{3}11$	" "	2
τ	—51	$\bar{5}11$	" "	2
α	$\frac{3}{2}$ $\frac{1}{2}$	312	" "	2
β	$2\frac{2}{3}$	623	" "	2
Ψ	62	621	" "	2
Ξ	—62	$\bar{6}21$	" "	2
v	84	841	" "	2
ω	—$\frac{8}{3}$ $\frac{4}{3}$	$\bar{8}43$	" "	2
V	$\frac{2}{7}$ $\frac{6}{7}$	267	" "	2
ϵ	—10.2	$\bar{1}0.2.1$	" "	2

1.—L. J. Spencer, 1897, Min. Mag., XI, p. 192.
2.—F. Zambonini, 1912, Riv. Min. Ital., XLI, p. 38.

Plumbojarosite

Hexagonal Rhombohedral *a: c* = 1:1.216

c	0	0001	Cooks Peak, N. Mex.	1
r	10	$10\bar{1}1$	" " "	1
s	—20	$02\bar{2}1$	" " "	1

1.—W. F. Hillebrand and W. T. Schaller, 1905, U. S. Geol. Surv., Bull. CCLXII, p. 35.

Podolite (Dahllite?)

Hexagonal *a: c* = ?

c	0	0001	Uschitza River, Podolien, Russia	1
m	∞0	$10\bar{1}0$	" " " "	1

1.—W. Tschirwinsky, 1907, Centralbl. f. Min., p. 279.

Polybasite

a: b: c = 1.7309:1:1.5796 $\beta = 90°$

c	0	001	Ouray, Colo.	1
l	3∞	310	" "	1
m	∞	110	" "	1
n	10	101	" "	1
Δ	$-\frac{2}{3}0$	$\bar{2}03$	" "	1
n°	-10	$\bar{1}01$	" "	1
π	$-\frac{4}{3}0$	$\bar{4}03$	" "	1
t°	-20	$\bar{2}01$	" "	1
o	$\frac{1}{4}$	114	" "	1
r	$\frac{1}{2}$	112	" "	1
p	1	111	" "	1
o	$\frac{4}{3}$	443	Tonopah, Nev.	2
s	2	221	Ouray, Colo.	1
u	3	331	" "	1
o°	$-\frac{1}{4}$	$\bar{1}14$	" "	1
r°	$-\frac{1}{2}$	$\bar{1}12$	" "	1
p°	-1	$\bar{1}11$	" "	1

1.—S. L. Penfield, 1896, Amer. Journ. Sci., II, p. 17.
2.— A. S. Eakle, 1912, Univ. Calif. Pub., VII, p. 1.

Polyhalite

a: b: c = 0.9314:1:0.8562 $\alpha = 92° 29'$ $\beta = 123° 4'$ $\gamma = 88° 21'$

P	0	001	Stassfurt, Germany	1
a	$\infty 0$	100	" "	1
M	0∞	010	" "	1
τ	$\infty\frac{5}{2}$	250	" "	1
ν	$\infty\frac{3}{2}$	230	" "	1
μ	2∞	210	" "	1
ξ	4∞	410	" "	1
λ	6∞	610	" "	1
l	-6∞	$\bar{6}10$	" "	1
m	-2∞	$\bar{2}10$	" "	1
n	$-\infty\frac{3}{2}$	$2\bar{3}0$	" "	1
t	$-\infty\frac{5}{2}$	$2\bar{5}0$	" "	1
π	01	011	" "	1
p	-01	$0\bar{1}1$	" "	1
o	-02	$0\bar{2}1$	" "	1
v	-03	$0\bar{3}1$	" "	1

w	—04	$0\bar{4}1$	Stassfurt, Germany	1
x	—01	$\bar{1}01$	" "	1
h	$\bar{2}2$	$\bar{2}21$	" "	1
δ	$\bar{1}\frac{3}{2}$	$\bar{2}32$	" "	1
d	$1\frac{3}{2}$	$\bar{2}\bar{3}2$	" "	1
ϵ	$\bar{1}\frac{1}{2}$	$\bar{2}12$	" "	1
e	$1\frac{1}{2}$	$\bar{2}\bar{1}2$	" "	1
r	$\bar{2}1$	$\bar{2}11$	" "	1
s	$\bar{2}\bar{1}$	$\bar{2}\bar{1}1$	" "	1
f	$\frac{1}{2}\frac{1}{4}$	$\bar{2}\bar{1}4$	" "	1
g	$\frac{1}{2}\frac{3}{1}$	$\bar{2}\bar{3}4$	" "	1
i	$\frac{1}{3}\frac{1}{6}$	$\bar{2}\bar{1}6$	" "	1

1.—R. Grögey, 1914, Wein Akad. Wiss. Math.-naturw., III, p. 3.

Powellite

e	10	101	South Hecla Mine, Haughton, Mich.					1
p	1	111	"	"	"	"	"	1
h	$\frac{1}{3}1$	133	"	"	"	"	"	1
j	$\frac{3}{11}1$	3.11.11	"	"	"	"	"	1
k	$\frac{1}{5}1$	155	"	"	"	"	"	1
l	$\frac{1}{11}1$	1.11.11	"	"	"	"	"	1

1.—C. Palache, 1899, Amer. Journ. Sci., VII, p. 367.

Prehnite

	4∞	410	Josvas Mine, Greenland	3
g	2∞	210	Scotland	2
e	$0\frac{1}{2}$	012	"	2
x	$\frac{1}{4}0$	104	"	2
φ	$\frac{2}{7}0$	207	Tafatal, Horn, Austria	4
	30	301	Josvas Mine, Greenland	3
	50	501	Garés Valley, Piedmont, Italy	1
	70	701	" " " "	1

1.—E. Billows, 1901, Riv. Min. Ital., XXVII.
2.—J. G. Goodchild, 1903, Trans. Geol. Soc. Glasgow, XII, Sup.
3.—O. B. Böggild, 1905, Min. om Grönland, p. 291.
4.—A. Himmelbauer, 1913, Min. Mitth., XXXII, p. 140.

Preslite

a: b: c = 0.9974:1:0.8215 $\beta = 81° 44'$

a	$\infty 0$	100	Tsumeb, Southwest Africa			1
d	10	101	"	"	"	1

o	—10	$\bar{1}01$	Tsumeb, Southwest Africa			1
p	1	111	"	"	"	1
n	2	221	"	"	"	1
s	$\frac{3}{2}1$	322	"	"	"	1
r	$\frac{9}{4}\frac{5}{2}$	9.10.4	"	"	"	1

1.—V. Rosičky, 1913, Zeitschr. f. Kryst., LI, p. 521.

Proustite

a: c = 1:0.8038

	10.0	10.0.$\bar{1}\bar{0}$.1	Bolivia	2
	13.0	13.0.$\bar{1}\bar{3}$.1	"	2
	—60	06$\bar{6}$1	"	2
Θ	$\frac{5}{9}\frac{2}{9}$	52$\bar{7}$9	Chile	1
Ψ	$\frac{4}{7}\frac{3}{7}$	43$\bar{7}$7	"	1
Φ	$\frac{5}{4}\frac{5}{12}$	15.5.$\bar{2}\bar{0}$.12	"	1
n^1	$4\frac{3}{2}$	8.3.$\bar{1}\bar{1}$.2	Markirch, Alsace, France	1

1.—H. A. Miers, 1888, Min. Mag., VIII, p. 37.
2.—E. E. Lamplough, 1903, Min. Mag., XIII, p. 294.

Pyrargyrite

a: c = 1:0.7892

h'	$\frac{5}{2}\infty$	52$\bar{7}$0	Ratiboric, Bohemia			5
f	3∞	31$\bar{4}$0	Andreasberg, Harz, Germany			1
	$\frac{9}{2}\infty$	9.2.$\bar{1}\bar{1}$.0	Nagybánya and Bojcza, Hungary			3+4
p''	$\frac{1}{6}$	11$\bar{2}$6	Mexico			2
π	$\frac{3}{2}0$	30$\bar{3}$2	Andreasberg, Harz, Germany			1
π'	$\frac{7}{19}\frac{6}{19}$	7.6.$\bar{1}\bar{3}$.19	"	"	"	1
Γ'	$\frac{2}{5}\frac{3}{10}$	4.3.$\bar{7}$.10	"	"	"	1
φ	$\frac{2}{3}\frac{1}{6}$	41$\bar{5}$6	"	"	"	1
G'	$\frac{7}{9}\frac{1}{9}$	71$\bar{8}$9	"	"	"	1
w'	$\frac{5}{4}\frac{1}{4}$	51$\bar{6}$4	"	"	"	1
ψ	$\frac{3}{2}\frac{1}{2}$	31$\bar{4}$2	"	"	"	1
s'	$\frac{7}{4}\frac{3}{4}$	7.3.$\bar{1}\bar{0}$.4	"	"	"	1
	$\frac{5}{3}\frac{2}{3}$	52$\bar{7}$3	Nagybánya, Hungary			4
Δ'	$\frac{17}{4}\frac{13}{4}$	17.13.$\bar{3}\bar{0}$.4	Freiberg, Germany			1
z	54	54$\bar{9}$1	Locality unknown			1
N'	$\frac{17}{2}\frac{15}{2}$	17.15.$\bar{3}\bar{2}$.2	Andreasberg, Harz, Germany			1
ρ	$\frac{2}{7}1$	27$\bar{9}$7	Locality unknown			1
B	$\frac{2}{3}\frac{1}{2}$	43$\bar{7}$6	Andreasberg, Harz, Germany			1

S	$\frac{2}{7}\ \frac{13}{7}$	2.13.$\overline{15}$.7	Freiberg, Germany	1
L	$\frac{5}{6}\ \frac{1}{2}$	53$\overline{8}$6	" "	1
m'	$\frac{6}{7}\ \frac{5}{7}$	6.5.$\overline{11}$.7	Braunsdorf, "	1
F'	$\frac{11}{12}\ \frac{1}{2}$	11.6.$\overline{17}$.12	Andreasberg, Harz, Germany	1
Ω	14	14$\overline{5}$1	" " "	
D	1.12	1.12.$\overline{13}$.1	Braunsdorf, Germany	1
Λ'	$\frac{1}{6}\ \frac{13}{6}$	1.13.$\overline{14}$.6	Přibram, Bohemia	5
Q	$\frac{14}{13}\ \frac{4}{13}$	14.4.$\overline{18}$.13	Andreasberg, Harz, Germany	1
C	$\frac{11}{10}\ \frac{2}{5}$	11.4.$\overline{15}$.10	" " "	1
V	$\frac{6}{5}\ \frac{1}{2}$	12.5.$\overline{17}$.10	" " "	1
p'	17.1	17.1.$\overline{18}$.1	" " "	1
o	$\frac{1}{6}\ \frac{5}{12}$	2.5.$\overline{7}$.12	Nagybánya, Hungary and Ratibaric, Bohemia	4+5

*1.—H. A. Miers, 1888, Min. Mag., VII, p. 37.
2.—K. Busz, 1892, Zeitschr. f. Kryst., XX, p. 529.
3.—V. Toborffy, 1910, Földt. Közlöny, XL, p. 435.
4.—K. Zimanyi, 1911, Ann. Mus. Nat. Hung., IX, p. 251.
5.—L. Kaplanova, 1912, Abh. d. böhm. Akad., No. 17.

Pyrite

I	$21\,\infty$	21.1.0	Ötösbánya, Zips, Hungary	13
$\mathfrak{p}$	$17\,\infty$	17.1.0	" " "	13
U	$15\,\infty$	15.1.0	" " "	13
H	$14\,\infty$	14.1.0	" " "	13
G	$12\,\infty$	12.1.0	" " "	13
A	$10\,\infty$	10.1.0	Spanish Peaks, Colo.	15
B	$8\,\infty$	810	Ötösbánya, Zips, Hungary	13
J	$\frac{11}{2}\,\infty$	11.2.0	" " "	13
C	$\frac{16}{3}\,\infty$	16.3.0	" " "	13
	$5\,\infty$	510	Valgioie, Piedmont, Italy	7
A	$\frac{11}{3}\,\infty$	11.3.0	Ötösbánya, Zips, Hungary	13
e_b	$\frac{16}{5}\,\infty$	16.5.0	Gilpin Co., Colo.	18
$\mathfrak{D}$	$\frac{8}{3}\,\infty$	830	Porkura, Siebenburgen, Hungary	11
$\mathfrak{E}$	$\frac{12}{5}\,\infty$	12.5.0	" " "	11
O	$\frac{7}{3}\,\infty$	730	Sajoháza, Gömör, Hungary	22
	$\frac{11}{5}\,\infty$	11.5.0	Belábánya, Honter, Hungary	3
	$\frac{13}{7}\,\infty$	13.7.0	Czehorszag, Bohemia	1
i	$\frac{9}{5}\,\infty$	950	Belábánya, Honter, Hungary	3
	$\frac{7}{4}\,\infty$	740	Spanish Peaks, Colo.	15
	$\frac{13}{9}\,\infty$	13.8.0	Belábánya, Honter, Hungary	3

χ	$\frac{8}{5}\infty$	850	Ötösbánya, Zips, Hungary	13
	$\frac{1\,3}{9}\infty$	13.9.0	Belábánya, Honter, Hungary	3
	$\frac{1\,0}{7}\infty$	10.7.0	" " "	3
	$\frac{1\,5}{1\,1}\infty$	15.11.0	" " "	3
e	$\frac{1\,3}{1\,0}\infty$	13.10.0	Gilpin Co., Colo.	18
Ξ	$\frac{1\,9}{1\,4}\infty$	19.14.0	Spanish Peaks, Colo.	26
j	$\frac{9}{7}\infty$	970	Belábánya, Honter, Hungary	3
	$\frac{1\,7}{1\,4}\infty$	17.14.0	Porkura, Siebenburgen, Hungary	11
Λ	$\frac{1\,1}{1\,0}\infty$	11.10.0	Ötösbánya, Zips, Hungary	13
	$\infty\frac{1\,4}{1\,3}$	13.14.0	Dognácska, Krasso-Szörény, Hun.	29
	$\infty\frac{1\,5}{1\,1}$	11.15.0	Belábánya, Honter, Hungary	3
D	$\infty\frac{7}{5}$	570	Spanish Peaks, Colo.	15
	$\infty\frac{1\,1}{7}$	7.11.0	Belábánya, Honter, Hungary	3
	$\infty\frac{1\,3}{8}$	8.13.0	" " "	3
	$\frac{6}{5}$	665	Cornwall, Pa.	16
	$\frac{5}{4}$	554	Valgioie, Piedmont, Italy	7
	$\frac{4}{3}$	443	Arnave, Haute-Garonne, France	2
	$\frac{7}{5}$	775	Valgioie, Piedmont, Italy	7
	$\frac{5}{3}$	553	" " "	7
	$\frac{7}{4}$	774	Cornwall, Pa.	16
	$\frac{7}{3}$	773	" "	16
	$\frac{5}{2}$	552	" "	16
	$\frac{1\,1}{1\,4}$	11.11.14	" "	16
s	71	711	Sajóháza, Gömör, Hungary	14
	$\frac{1\,1}{3}1$	11.3.3	Muso, Colombia, S. America	6
	$\frac{7}{2}1$	722	Dognácska, Krasso-Szörény, Hun.	24
ψ_1	$\frac{8}{3}1$	833	Kasejovic, Bohemia	30
	$\frac{7}{3}1$	733	Langeac, Haute-Loire, France	31
	$\frac{1\,5}{8}1$	15.8.8	Pokura, Siebenburgen, Hungary	19
	$\frac{1\,1}{6}1$	11.6.6	Dognácska, Krasso-Szörény, Hun.	27
	$\frac{9}{5}1$	955	" " "	27
	$\frac{5}{3}1$	533	Pokura, Siebenburgen, Hungary	11
	$\frac{8}{5}1$	855	Valgioie, Piedmont, Italy	7
	$\frac{1\,0}{7}1$	10.7.7	" " "	7
	$\frac{5}{4}1$	544	Pokura, Siebenburgen, Hungary	11
	$\frac{7}{6}1$	766	Dognácska, Krasso-Szörény, Hun.	27
	$\frac{1\,5}{1\,4}1$	15.14.14	Pokura, Siebenburgen, Hungary	11
χ	$\frac{7}{3}\,\frac{1}{6}$	14.1.6	Gilpin Co., Colo.	31
	82	821	Porkura, Siebenburgen, Hungary	11
ρ	$6\frac{3}{2}$	12.3.2	Elba, Italy	20

φ	$1\frac{1}{6}\ \frac{4}{6}$	11.4.6	Chamonix, Switzerland	31
σ	$4\frac{3}{2}$	832	Elba, Italy	20
	$4\frac{7}{4}$	16.7.4	Dognácska, Krasso-Szörény, Hun.	24
	52	521	Porkura, Siebenburgen, Hungary	8
	16.8	16.8.1	Dognácska, Krasso-Szörény, Hun.	29
	$9\frac{9}{2}$	18.9.2	Porkura, Siebenburgen, Hungary	11
	63	631	" " "	11
	$1\frac{6}{3}\ \frac{8}{3}$	16.8.3	Isère, France	31
	$5\frac{5}{2}$	10.5.2	Porkura, Siebenburgen, Hungary	11
	$\frac{5}{2}\ \frac{5}{4}$	10.5.4	Bald Mt., Boulder Co., Colo.	32
ω	$\frac{2}{1}\frac{0}{3}\ \frac{1}{1}\frac{0}{3}$	20.10.13	Gilpin Co., Colo.	31
ψ	$\frac{1}{9}\frac{0}{}\ \frac{5}{9}$	10.5.9		31
Γ	$\frac{2}{5}\ \frac{1}{5}$	215	Porkura, Siebenburgen, Hungary	8
$\flat$	13.7	13.7.1	Ötösbánya, Zips, Hungary	13
	95	951	" " "	13
	$\frac{9}{2}\ \frac{5}{2}$	952	Cornwall, Pa.	16
$\mathfrak{U}$	$1\frac{8}{5}\ 1\frac{0}{5}$	18.10.5	Fojnica, Herzegovina	12
α	$\frac{2}{2}\frac{3}{}\ 1\frac{3}{2}$	23.13.2	Steinbach, Thann, Alsace, France	31
	16.9	16.9.1	Belabánya, Siebenburgen, Hun.	3
$\dot{\jmath}$	74	741	Dognácska, Krasso-Szörény, Hun.	24
	$1\frac{0}{3}2$	10.6.3?	" " "	25
	$\frac{2}{6}\frac{5}{}\ \frac{5}{2}$	25.15.6	Ötösbánya, Zips, Hungary	13
$\flat$	$4\frac{5}{2}$	852	" " "	13
	$1\frac{6}{5}2$	16.10.5?	Dognácska, Krasso-Szörény, Hun.	25
	$\frac{8}{3}\ \frac{5}{3}$	853	Auriol, Bouches-du-Rhône, France	31
	$1\frac{2}{5}\ \frac{3}{2}$	24.15.10	Porkura, Siebenburgen, Hungary	11
	$1\frac{1}{5}\ \frac{7}{5}$	11.7.5	" "	11
	$1\frac{1}{6}\ \frac{7}{6}$	11.7.6	Almásel, Hungary	19
	$1\frac{4}{3}3$	14.9.3	Cornwall, Pa.	16
$\ddot{u}$	$\frac{7}{2}\ \frac{9}{4}$	14.9.4	Sajóháza, Gömör, Hungary	22
	64	641	Langeac, Haute-Loire, France	31
C	$\frac{9}{4}\ \frac{3}{2}$	964	Porkura, Siebenburgen, Hungary	10
	$2\frac{4}{3}$	643	Monzoni, Fassathal, Tyrol	9
ρ	10.7	10.7.1	Bingham, Utah	21
	$\frac{5}{2}\ \frac{7}{4}$	10.7.4	New York City	32
	$1\frac{4}{5}2$	14.10.5	Langeac, Haute-Loire, France	31
	$\frac{7}{3}\ \frac{5}{3}$	753	Cornwall, Pa.	16
	$\frac{7}{4}\ \frac{5}{4}$	754	Monzoni, Fassathal, Tyrol	9
	$1\frac{1}{5}\ \frac{8}{5}$	11.8.5	Porkura, Siebenburgen, Hungary	11
	$1\frac{5}{7}\ 1\frac{1}{7}$	15.11.7	" " "	11

φ	12.9	12.9.1	Bingham, Utah	21
ω	43	431	Spanish Peaks, Colo.	15
	$\frac{8}{3}2$	863	Almásel, Hungary	19
e	$\frac{14}{8}\,\frac{11}{8}$	14.11.8	Ötösbánya, Zips, Hungary	13
$\mathfrak{z}$	54	541	Montana	4
	$\frac{5}{2}2$	542	Cornwall, Pa.	16
	$\frac{9}{4}\,\frac{9}{5}$	45.36.20	Porkura, Siebenburgen, Hungary	11
	$\frac{5}{3}\,\frac{4}{3}$	543	" " "	11
$\mathfrak{a}$	$\frac{11}{7}\,\frac{9}{7}$	11.9.7	Ötösbánya, Zips, Hungary	13
$\mathfrak{D}$	$\frac{3}{2}\,\frac{5}{4}$	654	Fojnica, Herzegovina	12
	$2\frac{7}{4}$	874	Bald Mt. Boulder Co., Colo.	32
	$\frac{4}{3}\,\frac{7}{6}$	876	Cornwall, Pa.	16
	$\frac{9}{7}\,\frac{8}{7}$	987	Almásel, Hungary	19
	$\frac{10}{3}3$	10.9.3	Nagolny-Krjasch, Russia	17
η	$\frac{11}{5}2$	11.10.5	Gilpin Co., Colo.	31
	$\frac{6}{5}\,\frac{11}{10}$	12.11.10	Cornwall, Pa.	16
	$\frac{5}{3}2$	563	Dognácska, Krasso-Szörény, Hun.	27
$\mathfrak{B}$	$\frac{5}{4}\,\frac{3}{2}$	564	Fojnica, Herzegovina	12
r′	$\frac{8}{5}2$	8.10.5	Bingham, Utah	21
	$\frac{4}{3}2$	463	Dognácska, Krasso-Szörény, Hun.	24
	36	361	Merivaux, Belgium	5
$\mathfrak{w}$	$\frac{11}{7}\,\frac{22}{7}$	11.22.7	Ötösbánya, Zips, Hungary	13
	$\frac{4}{3}\,\frac{8}{3}$	483	Dognácska, Krasso-Szörény, Hun.	24
O	37	371	Bingham, Utah	21
	$\frac{5}{2}10$	5.20.2	Dognácska, Krasso-Szörény, Hun.	24

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Pyroaurite

Hexagonal $a:c = 1:1.6557$

c	0	0001	Moss Mine, Moss, Norway				1
m	$\infty 0$	$10\bar{1}0$	"	"	"	"	1
h	2∞	$21\bar{3}0$	"	"	"	"	1
r	10	$10\bar{1}1$	"	"	"	"	1
g	40	$40\bar{4}1$	"	"	"	"	2
f	—20	$02\bar{2}1$	"	"	"	"	2

1.—Hj. Sjögren, 1895, Bull. Geol. Inst. Upsala, II, p. 59.
2.—G. Flink, 1900, Bull. Geol. Inst. Upsala, V, p. 81.

Pyrobelonite

$a:b:c = 0.80402:1:0.65091$

c	0	001	Långban, Sweden		1
a	$\infty 0$	100	"	"	1
m	∞	110	"	"	1
n	$\infty 2$	120	"	"	1
d	01	011	"	"	1
f	03	031	"	"	1
e	20	201	"	"	1
p	1	111	"	"	1
o	2	221	"	"	1

1.—G. Flink, 1919, Geol. Fören. Förh., XLI, p. 433.

Pyrochroite

p	$\frac{1}{4}0$	$10\bar{1}4$	Långban, Sweden		1
o	$\frac{1}{2}0$	$10\bar{1}2$	"	"	2
q	$\frac{3}{4}0$	$30\bar{3}4$	"	"	2

1.—G. Flink, 1901, Bull. Geol. Inst. Uosala, V, p. 97.
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Pyrolusite

a: b: c = 0.8612:1:0.5629

A	$0\frac{1}{8}$	018	Powells Fort, Shenandoah Co., Va.	1
B	$0\frac{1}{4}$	014	" " " "	1
C	$0\frac{1}{3}$	013	" " " "	1
D	$0\frac{1}{2}$	012	" " " "	1
F	$0\frac{3}{2}$	032	" " " "	1
Z	$\frac{5}{6}1$	566	" " " "	1
X	$\frac{3}{2}\ \frac{5}{4}$	654	" " " "	1

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Pyromorphite

h	2∞	$21\bar{3}0$	Ems, Nassau, Germany	3
ϵ	$\frac{3}{4}0$	$30\bar{3}4$	Moye Dist. B. Col.	2
	$1\frac{5}{4}0$	$15.0.\bar{15}.4$	New Caledonia	1
	90	$90\bar{9}1$	" "	1
u	21	$21\bar{3}1$	Broken Hill, N. S. Wales	3

1.—A. Lacroix, 1894, Bull. Soc. fr. Min., XVII, p. 120.
2.—O. Bowles, 1909, Amer. Journ. Sci., XXVIII, p. 40.
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Pyrosmaltite

Hexagonal *a: c* = 1:0.5308

c	0	0001	Nordmark, Sweden	1
m	$\infty 0$	$10\bar{1}0$	" "	1
t	$\frac{1}{2}0$	$10\bar{1}2$	" "	1
r	10	$10\bar{1}1$	" "	1
s	20	$20\bar{2}1$	" "	1
z	—10	$01\bar{1}1$	" "	1

1.—G. Flink, 1917, Ark. Kemi. Min. Geol., VI, No. 21.

Pyroxene Group

$\mathfrak{F}$	10∞	10.1.0	Zillerthal, Tyrol	4
$\mathfrak{C}$	7∞	710	Arany Mts., Piski, Siebenburgen, Hungary	4
$\mathfrak{T}$	$\frac{5}{3}\infty$	530	Waimea Canyon, Hawaii	12
$\mathfrak{H}$	$\frac{7}{5}\infty$	750	Zillerthal, Tyrol	4
Θ	$\infty\frac{3}{2}$	230	Waimea Canyon, Hawaii	12
	$\infty\frac{5}{3}$	350	Salzburg, Germany	1
$\mathfrak{K}$	$\infty 4$	140	Zillerthal, Tyrol	4

$\mathfrak{M}$	$\infty 6$	160	Nordmark, Sweden	4
$\mathfrak{N}$	$0\frac{1}{5}^{1}$	0.11.5	Achmatovsk, Ural Mts., Russia	4
$\mathfrak{h}$	03	031	New York City	11
	$\frac{1}{3}0$	103	Yoneyama, Echigo, Japan	6
	40	401	Ala, Tyrol	10
	$-\frac{2}{3}0$	$\bar{2}03$	Yoneyama, Echigo, Japan	6
$\mathfrak{B}$	$-\frac{6}{5}0$	$\bar{6}05$	Canale Monterano, Rome, Italy	8
	$-\frac{3}{2}0$	$\bar{3}02$	Prinzgau	2
u_1	$\frac{6}{5}$	665	Sau Alp, Tyrol	9
h'	5	551	Achmatovsk, Ural Mts., Russia	3
	—4	$\bar{4}41$	Prinzgau	2
λ_2	$-\frac{5}{2}$	$\bar{5}52$	Zillerthal, Tyrol	9
	$-\frac{4}{3}$	$\bar{4}43$	" "	9
$\mathfrak{B}$	—16	$\bar{1}61$	Capo di Bove, Rome, Italy	5
	—14	$\bar{1}41$	" " "	5
$\mathfrak{v}$	$-1\frac{4}{3}$	$\bar{3}43$	Ala, Tyrol	5
$\mathfrak{S}$	$-1\frac{1}{4}$	$\bar{4}14$	Arany Mts. Piski, Siebenburgen, Hungary	4
B	41	411	Ala, Tyrol	10
$\mathfrak{w}$	14.1	14.1.1	" "	5
v	$-\frac{1}{3}1$	$\bar{1}33$	" "	9
G	—3.12	$\bar{3}.12.1$	Capo di Bove, Rome, Italy	5
F	—36	$\bar{3}61$	" " "	5
	$-\frac{1}{10}\frac{1}{5}$	$\bar{1}.2.10$	Prinzgau	2
$\mathfrak{n}$	—23	$\bar{2}31$	Crestmore, Riverside Co., Calif.	13
$\mathfrak{i}$	—32	$\bar{3}21$	New York City	11
$\mathfrak{U}$	43	431	Lacher See, Germany	7
$\mathfrak{M}$	—53	$\bar{5}31$	Achmatovsk, Ural Mts., Russia	4
$\mathfrak{B}$	—42	$\bar{4}21$	" " "	4
$\mathfrak{H}$	—62	$\bar{6}21$	Capo di Bore, Rome, Italy	5

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QUARTZ

	46.0	46.0.$\bar{4}\bar{6}$.1	Bourge d'Oisans, Dauphiné, France	8
	20.0	20.0.$\bar{2}\bar{0}$.1	Nagolnij Krjasch, Don Cossacks, Russia	11
	$\frac{16}{3}$0	16.0.$\bar{1}\bar{6}$.3	Wurmthal, Harz, Germany	6
Ψ.	11.0	11.0.$\bar{1}\bar{1}$.1	Hancock, Mich.	10
	$\frac{14}{3}$0	14.0.$\bar{1}\bar{4}$.3	Val Malenco, Lombardy, Italy	3
	$\frac{41}{11}$0	41.0.$\bar{4}\bar{1}$.11	Meylan, Isère, France	7
η:	$\frac{7}{2}$0	70$\bar{7}$2	Alexander Co., N. C.	13
Θ	$\frac{10}{3}$0	10.0.$\bar{1}\bar{0}$.3	" "	13
	$\frac{23}{7}$0	23.0.$\bar{2}\bar{3}$.7	Carrara, Tuscany, Italy	12
ω'	$\frac{5}{2}$0	50$\bar{5}$2	Alexander Co., N. C.	13
	$\frac{8}{5}$0	80$\bar{8}$5	Meylan, Isère, France	7
	$\frac{7}{5}$0	70$\bar{7}$5	Zillerthal, Tyrol	2
	$\frac{13}{10}$0	13.0.$\bar{1}\bar{3}$.10	Wurmthal, Harz, Germany	6
u	$\frac{9}{7}$0	90$\bar{9}$7	Hancock, Mich.	10
	$\frac{16}{13}$0	16.0.$\bar{1}\bar{6}$.13	Wurmthal, Harz, Germany	6
	$\frac{7}{6}$0	70$\bar{7}$6	Val Malenco, Lombardy, Italy	3
	$\frac{8}{7}$0	80$\bar{8}$7	Carrara, Tuscany, Italy	12
x	$\frac{4}{5}$0	40$\bar{4}$5	Herkimer, N. Y.	10
ϵ.	$\frac{1}{3}$0	10$\bar{1}$3?	" "	10
v	$\frac{1}{5}$0	10$\bar{1}$5?	" "	10
y:	$-\frac{3}{5}$0	03$\bar{3}$5?	" "	10
w	$-\frac{3}{4}$0	03$\bar{3}$4	" "	10
x:	$-\frac{4}{5}$0	04$\bar{4}$5	" "	10
	$-\frac{11}{10}$0	0.11.$\bar{1}\bar{1}$.10	Meylan, Isère, France	7
Φ	$-\frac{9}{7}$0	09$\bar{9}$7	Alexander, Co., N. C.	13
	$-\frac{23}{10}$0	0.23.$\bar{2}\bar{3}$.16	Wurmthal, Harz, Germany	6
	$-\frac{11}{7}$0	0.11.$\bar{1}\bar{1}$.7	Meylan, Isère, France	7
	$-\frac{5}{3}$0	05$\bar{5}$3	Wurmthal, Harz, Germany	6
	$-\frac{19}{11}$0	0.19.$\bar{1}\bar{9}$.11	Meylan, Isère, France	7
	$-\frac{7}{4}$0	07$\bar{7}$4	Grindelwald, Switzerland	5
	$-\frac{13}{7}$0	0.13.$\bar{1}\bar{3}$.7	Wurmthal, Harz, Germany	6
	$-\frac{13}{6}$0	0.13.$\bar{1}\bar{3}$.6	" " "	6
Θ	$-\frac{10}{3}$0	0.10.$\bar{1}\bar{0}$.3	Alexander Co., N. C.	13
μ	$-\frac{11}{2}$0	0.11.$\bar{1}\bar{1}$.2	Sanarka, Ural Mts., Russia	14
	$\frac{1}{2}$	11$\bar{2}$2	Grindelwald, Switzerland	5
	$1\frac{1}{11}$	11.1.$\bar{1}\bar{2}$.11	Val Malenco, Lombardy, Italy	3
W'	$1\frac{1}{8}$	81$\bar{9}$8	Hancock, Mich.	10
	$1\frac{3}{22}$	22.3.$\bar{2}\bar{5}$.22	Meylan, Isère, France	7

	$1\frac{1}{7}$	$\left\{\begin{matrix}7\bar{1}87\\8\bar{1}77\end{matrix}\right\}$	Val Malenco, Lombardy, Italy	1
	$1\frac{6}{11}$	11.6.$\bar{1}$7.11	Meylan, Isère, France	7
	$1\frac{2}{2}\frac{5}{6}$	26.15.$\bar{4}$1.26	" " "	7
	$1\frac{5}{8}$	$\left\{\begin{matrix}8.5.\bar{1}3.8\\13.\bar{5}.\bar{8}.8\end{matrix}\right\}$	Val Malenco, Lombardy, Italy	1
	$1\frac{1}{1}\frac{5}{9}$	19.$\bar{1}$5.$\bar{3}$4.19	Meylan, Isère, France	7
	$1\frac{3}{4}\frac{0}{1}$	41.30.$\bar{7}\bar{1}$.41	" " "	7
	$1\frac{7}{6}$	$\left\{\begin{matrix}7.6.\bar{1}3.7\\13.\bar{6}.7.7\end{matrix}\right\}$	Val Malenco, Lombardy, Italy	1
n:	$\frac{1}{3}\frac{0}{}1$	10.3.$\bar{1}$3.3	Alexander Co., N. C.	13
y'	$\frac{2}{5}\frac{9}{}1$	$\bar{2}\bar{2}$.5.$\bar{2}\bar{7}$.5	Baveno, Piedmont, Italy	9
	23.1	$\left\{\begin{matrix}23.1.\bar{2}4.1\\24.1.\bar{2}3.1\end{matrix}\right\}$	Carrara, Tuscany, Italy Alexander Co., N. C.	12 13
	35.1	35.1.$\bar{3}$6.1	Carrara, Tuscany, Italy	12
	$\frac{4}{7}\frac{3}{7}$	4$\bar{3}\bar{7}$7	Meylan, Isère, France	7
	$\frac{5}{8}\frac{3}{8}$	5$\bar{3}\bar{8}$8	" " "	7
b:	$\frac{6}{1}\frac{3}{3}\frac{3}{1}\frac{3}{3}$	6.3.$\bar{9}$.13	Herkimer, N. Y.	10
	$\frac{3}{4}\frac{2}{7}\frac{1}{4}\frac{5}{7}$	32.15.$\bar{4}\bar{7}$.47	Meylan, Isère, France	7
c:	$\frac{9}{7}\frac{3}{7}$	9.3.$\bar{1}\bar{2}$.7?	Herkimer, N. Y.	10
	$\frac{1}{1}\frac{3}{6}\frac{3}{1}\frac{3}{6}$	13.3.$\bar{1}$6.16	Meylan, Isère, France	7
Q:	$\frac{2}{3}\frac{1}{9}$	61$\bar{7}$9	Herkimer, N. Y.	10
F	$\frac{1}{2}\frac{3}{1}\frac{3}{7}$	22.9.$\bar{1}$3.21	Baveno, Piedmont, Italy	9
	$\frac{4}{5}\frac{1}{1}\frac{}{0}$	8.1.$\bar{9}$.10	Zillerthal, Tyrol	2
	$\frac{3}{9}\frac{7}{}\frac{1}{9}$	37.1.$\bar{3}\bar{8}$.9	Gärde, Sweden	4
	$\frac{4}{9}\frac{4}{}\frac{1}{9}$	44.1.45.9	" "	4
	$\frac{7}{8}\frac{1}{4}$	9$\bar{2}\bar{7}$8	Zillerthal, Tyrol	2
	$\frac{1}{1}\frac{7}{2}\frac{5}{4}$	32.$\bar{1}$5.$\bar{1}$7.12	Grindelwald, Switzerland	5
	$-1\frac{1}{2}\frac{}{9}$	$\bar{1}$.30.$\bar{2}\bar{9}$.29	Meylan, Isère, France	7
U:	$-1\frac{5}{9}$	$\bar{9}$.$\bar{5}$.14.9	Herkimer, N. Y.	10
V:	$-1\frac{8}{1}\frac{}{5}$	$\bar{1}\bar{5}$.$\bar{8}$.23.15	" "	10
T:	$-1\frac{7}{1}\frac{}{2}$	$\bar{1}\bar{2}$.$\bar{7}$.19.12	" "	10
L:	$-1\frac{5}{3}$	$\bar{3}\bar{2}$53	" "	10
K:	$-1\frac{7}{4}$	$\bar{4}$374	" "	10
	$-\frac{9}{8}1$	$\bar{8}$.17.$\bar{9}$.8	Val Malenco, Lombardy, Italy	1
	$-\frac{5}{4}1$	$\left\{\begin{matrix}\bar{4}9\bar{5}4\\45\bar{9}4\end{matrix}\right\}$	" " "	1
	$-\frac{4}{3}1$	$\left\{\begin{matrix}37\bar{4}3\\34\bar{7}3\end{matrix}\right\}$	" " "	1

	$-\frac{7}{5}1$	$\left\{\begin{matrix}\bar{5}.12.\bar{7}.5\\5.7.\bar{12}.5\end{matrix}\right\}$	Val Malenco, Lombardy, Italy	1
	$-\frac{15}{7}1$	$\left\{\begin{matrix}\bar{7}.22.\bar{15}.7\\7.15.\bar{22}.7\end{matrix}\right\}$	" " "	1
𝔘.	$-\frac{9}{4}1$	$\bar{4}.13.\bar{9}.4$	Sanarka, Ural Mts., Russia	14
	$-\frac{12}{5}1$	$\bar{5}.12.\bar{7}.5$	Carrara, Tuscany, Italy	12
	$-\frac{5}{2}1$	$\left\{\begin{matrix}\bar{2}7\bar{5}2\\2\bar{5}72\end{matrix}\right\}$	Val Malenco, Lombardy, Italy	3
𝔫.	$-\frac{10}{3}1$	$\bar{10}.\bar{3}.13.3$	Alexander Co., N. C.	13
ℭ.	$-\frac{9}{2}1$	$\bar{2}.11.\bar{9}.2$	Sanarka, Ural Mts., Russia	14
ℌ.	-61	$\bar{1}7\bar{6}1$	" " "	14
	-12.1	$13.\bar{12}.\bar{1}.1$	Gärde, Sweden	4
	-27.1	$28.\bar{27}.\bar{1}.1$	" "	4
	$-\frac{6}{5}\frac{1}{10}$	$\left\{\begin{matrix}\bar{1}.13.\bar{12}.10\\1.12.\bar{13}.10\end{matrix}\right\}$	Val Malenco, Lombardy, Italy	1
	$-\frac{12}{11}\frac{2}{11}$	$\left\{\begin{matrix}\bar{2}.14.\bar{12}.11\\2.12.\bar{14}.11\end{matrix}\right\}$	" " "	1
T:	$-\frac{11}{12}\frac{2}{3}$	$\bar{11}.\bar{8}.19.12$	Herkimer, N. Y.	10
β:	$-\frac{4}{11}\frac{3}{11}$	$\bar{4}.\bar{3}.7.11$	" "	10
ϑ:	$-\frac{7}{16}\frac{1}{8}$	$\bar{7}.\bar{2}.9.16$	" "	10
α:	$-\frac{9}{11}\frac{1}{11}$	$\bar{9}.\bar{1}.10.11$	" "	10
	$-\frac{15}{16}\frac{1}{16}$	$1.15.\bar{16}.16$	Meylan, Isère, France	7
	$-\frac{15}{17}\frac{2}{17}$	$2.15.\bar{17}.17$	" " "	7
	$-\frac{6}{7}\frac{1}{7}$	$16\bar{7}7$	" " "	7
	$-\frac{20}{21}\frac{4}{21}$	$4.20.\bar{24}.21$	Val Malenco, Lombardy, Italy	1
	$-\frac{5}{7}\frac{2}{7}$	$25\bar{7}7$	Meylan, Isère, France	7

1.—E. Artini, 1888, Mem. Accad. Linc., (14) V.
2.—A. Cathrein, 1889, Zeitschr. f. Kryst., XVII, p. 19.
3.—D. Rossignoli, 1892, Riv. Min. Ital., X, p. 3.
4.—A. Hamberg, 1894, Geol. Fören. Förh., XVI, p. 307.
5.—P. Termier, 1895, Bull. Soc. fr. Min., XVIII, p. 443.
6.—O. Luedecke, 1896, Min. d. Harzes, p. 196.
7.—F. Gonnard, 1899, Bull. Soc. fr. Min., XXII, p. 94.
8.—F. Gonnard, 1901, Zeitschr. f. Kryst., XXXIV, p. 279.
9.—F. Gonnard, 1902, Bull. Soc. fr. Min., XXV, p. 90.
*10.—G. Lincio, 1904, Neues Jahrb. f. Min., B.-B., XVIII, p. 155.
11.—J. Samojloff, 1906, Mater. z. geol. Russl., XXIII.
12.—P. Aloisi, 1909, Att. Soc. Tosc., Mem., XXV, p. 87.
13.—J. E. Pogue and V. Goldschmidt, 1912, Amer. Journ. Sci., XXXIV, p. 414.
14.—G. Aminoff, 1919, Ark. Kemi. Min. Geol., VII, No. 17.

Raspite

$a:b:c = 1.34497:1:1.11468 \quad \beta = 72° 23'$

c	0	001	Broken Hill, N. S. Wales			1
a	$\infty 0$	100	"	"	"	1
b	0∞	010	"	"	"	1
m	∞	100	"	"	"	1
d	01	011	"	"	"	1
e	—10	$\bar{1}01$	"	"	"	1
f	$-\frac{1}{2}0$	$\bar{1}02$	"	"	"	1
p	$\frac{1}{2}1$	122	"	"	"	1
δ	$\frac{1}{1\,2}1$	1.12.12	"	"	"	1

1.—C. Hlawatsch, 1897, Zeitschr. f. Kryst., XXIX, p. 137; 1906, idem, XLII, p. 587.

Rathite

$a:b:c = 1.5869:1:1.0698 \quad \beta = 79° 16'$

c	0	001	Binnenthal, Switzerland			1
A	$\infty 0$	100	"	"		1
	0∞	010	"	"		2
	20∞	20.1.0	"	"		2
	$\frac{2\,7}{2} \infty$	27.2.0	"	"		2
	$\frac{3\,3}{4} \infty$	33.4.0	"	"		2
	$\frac{1\,5}{2} \infty$	15.2.0	"	"		2
	$\frac{2\,7}{4} \infty$	27.4.0	"	"		1
	6∞	610	"	"		1
	$\frac{1\,1}{2} \infty$	11.2.0	"	"		1
	$\frac{2\,1}{4} \infty$	21.4.0	"	"		2
Θ	5∞	510	"	"		1
ρ	$\frac{9}{2} \infty$	920	"	"		1
	$\frac{1\,7}{4} \infty$	17.4.0	"	"		1
	4∞	410	"	"		2
	$\frac{7}{2} \infty$	720	"	"		1
l	3∞	310	"	"		1
	$\frac{1\,1}{4} \infty$	11.4.0	"	"		1
ψ	$\frac{5}{2} \infty$	520	"	"		1
	$\frac{9}{4} \infty$	940	"	"		2
r	2∞	210	"	"		1
	$\frac{1\,5}{8} \infty$	15.8.0	"	"		2
	$\frac{7}{4} \infty$	740	"	"		2
	$\frac{2\,7}{1\,6} \infty$	27.16.0	"	"		1

	$\frac{2}{1}\frac{1}{6}\infty$	21.16.0	Binnenthal, Switzerland		2
s	$\frac{3}{2}\infty$	320	"	"	1
	$\frac{5}{4}\infty$	540	"	"	1
	$\frac{6}{5}\infty$	650	"	"	3
m	∞	110	"	"	1
ω	$\infty\frac{4}{3}$	340	"	"	1
	$\infty\frac{3}{2}\frac{2}{1}$	21.32.0	"	"	1
f	$\infty 2$	120	"	"	1
α	$\infty\frac{5}{2}$	250	"	"	3
	$\infty\frac{8}{3}$	380	"	"	2
	$\infty 4$	140	"	"	1
	$\infty\frac{1}{3}6$	3.16.0	"	"	2
	$\infty 6$	160	"	"	1
	$\infty\frac{2}{3}8$	3.28.0	"	"	2
	$\infty\frac{3}{3}2$	3.32.0	"	"	2
γ	$0\frac{1}{2}$	012	"	"	3
n	01	011	"	"	2
	$0\frac{3}{2}$	032	"	"	2
	$\frac{3}{8}0$	308	"	"	2
	$\frac{1}{4}\frac{9}{4}0$	19.0.44	"	"	1
φ	$\frac{1}{2}0$	102	"	"	2
	$\frac{3}{4}0$	304	"	"	2
d	10	101	"	"	1
	$\frac{1}{1}\frac{7}{6}0$	17.0.16	"	"	2
	$\frac{1}{1}\frac{1}{0}0$	11.0.10	"	"	2
s	$\frac{3}{2}0$	302	"	"	1
	$\frac{7}{4}0$	704	"	"	2
t	20	201	"	"	2
	$\frac{1}{8}\frac{9}{}0$	19.0.8	"	"	2
	$\frac{7}{2}0$	702	"	"	2
h	30	301	"	"	3
	40	401?	"	"	3
	50	501	"	"	2
	11.0	11.0.1	"	"	2
y	—20	$\bar{2}01$	"	"	3
χ	$-\frac{3}{2}0$	$\bar{3}02$	"	"	3
z	—10	$\bar{1}01$	"	"	3
u	$-\frac{2}{3}0$	$\bar{2}03$	"	"	3
w	$-\frac{1}{2}0$	$\bar{1}02$	"	"	3
Σ	$\frac{1}{2}$	112	"	"	3

g	1	111	Binnenthal, Switzerland	2
p	—1	$\bar{1}11$	" "	3
Δ	—$\frac{1}{2}$	$\bar{1}12$	" "	3
α	$\frac{1}{2}$1	122	" "	2
τ	$\frac{3}{4}$1	344	" "	3
e	$\frac{3}{2}$1	322	" "	2
δ	21	211	" "	2
k	$\frac{5}{2}$1	522	" "	2
	$1\frac{3}{4}$1	13.4.4	" "	2
	—$\frac{1}{10}$1	$\bar{1}$.10.10	" "	2
o	—$\frac{1}{2}$1	$\bar{1}22$	" "	3
x	—$\frac{3}{2}$1	$\bar{3}22$	" "	3
λ	—21	$\bar{2}11$	" "	3
k	—$\frac{5}{2}$1	$\bar{5}22$	" "	3
i	—31	$\bar{3}11$	" "	3
	$\frac{1}{2}$2	142	" "	2
	$\frac{3}{2}$ $\frac{1}{2}$	312	" "	2
μ	—$\frac{3}{2}$ $\frac{1}{2}$	$\bar{3}12$	" "	3
η	—$\frac{5}{4}$ $\frac{1}{2}$	$\bar{5}24$	" "	3
π	—1$\frac{1}{2}$	$\bar{2}12$	" "	3
ϵ	—$\frac{3}{4}$ $\frac{1}{2}$	$\bar{3}24$	" "	3

1.—H. Baumhauer, 1896, Zeitschr. f. Kryst., XXVI, p. 593.
2.—R. H. Solly, 1901, Min. Mag., XIII, p. 77.
*3.—W. J. Lewis, 1912, Min. Mag., XVI, p. 197.

Realger

a: b: c = 0.7203:1:0.4858 β = 66° 16′

ζ	∞$\frac{5}{4}$	450	Alchar, Macedonia	3
s	∞$\frac{5}{2}$	250	Bosnia	1
u	0$\frac{6}{5}$	065?	Felsöbánya, Hungary	4
C	—1$\frac{1}{3}$	$\bar{3}13$?	Monte Amiata, Tuscany, Italy	2
o	—32	$\bar{3}21$	Felsöbánya, Hungary	4

1.—C. Vrba, 1889, Zeitschr. f. Kryst., XV, p. 449.
2.—G. Grattarola, 1890, Giorn. d. Min., I, p. 278.
3.—V. Hackmann, 1896, Zeitschr. f. Kryst., XXVII, p. 608.
4.—M. Löw, 1912, Zeitschr. f. Kryst., LI, p. 132.
*5.—V. Goldschmidt, 1904, Zeitschr. f. Kryst., XXXIX, p. 113.

Retzian

a: b: c = 0.4414:1:0.7269

b	0∞	010	Moss Mine, Nordmark, Sweden	1
m	∞	110	" " " "	1

n	$\infty 3$	130	Moss Mine, Nordmark, Sweden	1
k	07	071	" " " "	1
d	10	101	" " " "	1

1.—H. Sjögren, 1894, Bull. Geol. Inst. Upsala, II, p. 54.

Rhodonite

$a:b:c = 1.0737:1:0.62115 \quad \alpha = 103° 18' \quad \beta = 108° 44' \quad \gamma = 81° 39'$

A	$0\frac{1}{3}$	013	Broken Hill, N. S. Wales	3
B	$-0\frac{1}{5}$	$0\bar{1}5$	" " "	3
C	$-0\frac{1}{4}$	$0\bar{1}4$	" " "	3
Θ	$-0\frac{1}{3}$	$0\bar{1}3$	Pajsberg, Vermland, Sweden	2
E	$-0\frac{3}{7}$	$0\bar{3}7$	Broken Hill, N. S. Wales	3
V	-04	$0\bar{4}1$	Franklin Furnace, N. J.	4
ϵ	20	201	" " "	1
G	$\frac{2}{7}0$	207	Broken Hill, N. S. Wales	3
F	$\frac{1}{3}0$	103	" " "	3
	$-\frac{4}{3}0$	$\bar{4}03$	Franklin Furnace, N. J.	6
H	-20	$20\bar{1}$	Broken Hill, N. S. Wales	3
K	$\frac{1}{3}\,\frac{1}{3}$	$11\bar{3}$	" " "	3
L	$\frac{1}{2}\,\frac{1}{2}$	$11\bar{2}$	" " "	3
ϵ	$\bar{2}\bar{2}$	$22\bar{1}$	Långban, Sweden	5
	$2\bar{2}$	$2\bar{2}1$	Franklin Furnace, N. J.	6
s	$\bar{3}\bar{3}$	$33\bar{1}$	Långban, Sweden	5
	$\frac{4}{3}\,\frac{2}{3}$	423	Pajsberg, Vermland, Sweden	2

1.—L. V. Pirsson, 1890, Amer. Journ. Sci., XL, p. 484.
2.—A. Hamberg, 1891, Geol. Fören. Förh., XIII, p. 539.
3.—C. Anderson, 1908, Rec. Austr. Mus., VII, p. 129.
4.—W. E. Ford and R. D. Crawford, 1911, Amer. Journ. Sci., XXXII, p. 289.
5.—G. Flink, 1905, Ark. Kemi. Min. Geol., V, No. 10.
6.—Lazard Cahn, 1919, Privately contributed.

Rhonite

Triclinic Isomorphous with Aenigmite

c	0	001	Bruckenau, Rhön, Germany	1
a	$\infty 0$	100	" " "	1
b	0∞	010	" " "	1
m	∞	$1\bar{1}0$	" " "	1
μ	$-\infty$	$\bar{1}10$	" " "	1
k	$1\bar{1}$	$11\bar{1}$	" " "	1
r	$\bar{1}\bar{1}$	$\bar{1}\bar{1}\bar{1}$	" " "	1

v	$1\bar{3}$	$1\bar{3}1$	Bruckenau, Rhön, Germany	1
i	$\bar{1}3$	$\bar{1}31$	" " "	1

1.—J. Soellner, 1907, Neues Jahrb. f. Min., Beil.-B., XXIV, p. 475.

Reibeckite

a: b: c = 0.5475:1:0.2925 $\beta = 76° 10'$

c	0	001	East Coast of Ireland	1
b	0∞	010	" "	1
m	∞	110	" "	1
z	$\infty 5$	150	" "	1
Z	02	021	" "	1
t	—20	$\bar{2}01$	" "	1
r	—1	$\bar{1}11$	" "	1

1.—W. J. Sollas, 1895, Proc. R. Irish. Acad., III, p. 516.

Rinneite

Hexagonal Rhombohedral *a: c* = 1:0.576—

	0	0001	Hildesheim, Hannover, Germany	1
	∞	$11\bar{2}0$	" " "	1
	10	$10\bar{1}1$	" " "	1

1.—Boeke, 1909, Neues Jahrb. f. Min., II, p. 19.

Romeite

Isometric

a	$\infty 0$	100	Minas Geras, Brazil	3
d	∞	110	San Marcel, Valle d'Aosta, Italy	1
o	1	111	" " "	1
m	31	311	" " "	1
n	21	211	" " "	1
v	$\frac{1}{3}$	113	Minas Gereas, Brazil	2

1.—A. Pelloux,, 1913, Mus. civ. historia-nat. Genova, Ann., VI, p. 22.
2.—R. Schröder, 1913, Goldschmidt's Atlas d. Krystallf., I, p. 121.
3.—W. T. Schaller, 1916, U. S. Geol. Surv., Bull. DCX, p. 95.

Roschérite

a: b: c = 0.94:1:0.88 $\beta = 99° 50'$

c	0	001	Ehrensfriedersdorf, Saxony, Ger.	1
a	$\infty 0$	100	" " "	1
b	0∞	010	" " "	1
m	∞	110	" " "	1
d	—10	$\bar{1}01$	" " "	1

1.—F. Slavic, 1914, Abh. d. böhm. Akad., No. 4.

Rutile

M	$\frac{9}{2}\infty$	920	Minas Geraes, Brazil	1
K	$\frac{7}{2}\infty$	720	Bahia, Brazil	3
F	$\frac{5}{2}\infty$	520	" "	3
E	$\frac{8}{3}\infty$	830	" "	3
L	$\frac{1}{5}\frac{1}{1}\infty$	11.5.0	" "	3
D	$\frac{3}{2}\frac{7}{0}\infty$	37.20.0	" "	3
K	$\frac{5}{4}\infty$	540	Minas Geraes, Brazil	1
ϵ	$\frac{1}{7}$	117	Hörsjoberg, Sweden	2

1.—J. Krizsó, 1909, Földt. Közlöny, XXXIX, p. 497.
2.—G. Flink, 1910, Ark. Kemi. Min. Geol., III.
3.—P. Siedel, 1915, Neues Jahrb. f. Min., Beil-B., XXXVIII, p. 784.

Safflorite

a: b: c = 0.59101:1:1.149 (Flink)

c	0	001	Ko Mine, Nordmark, Sweden			1
a	$\infty 0$	100	"	"	"	1
m	∞	110	"	"	"	1
d	01	011	"	"	"	1
o	1	111	"	"	"	1

1.—H. Sjögren, 1894, Bull. Geol. Inst. Upsala, II, p. 68.
2.—G. Flink, 1908, Ark. Kemi. Min. Geol., III, No. 11, p. 71.

Samirésite

Isometric

	1	111	Antsirabe, Madagascar	1

1.—A. Lacroix, 1912, Bull. Soc. fr. Min., XXXV, p. 84.

Samsonite

a: b: c = 1.2777:1:0.819 $\beta = 92° 42'$

c	0	001	Samson Vein, Andreasberg, Harz, Ger.					1
a	$\infty 0$	100	"	"	"	"	"	2
b	0∞	010	"	"	"	"	"	1
l	2∞	210	"	"	"	"	"	2
m	∞	110	"	"	"	"	"	2
	$\infty\frac{5}{4}$	450	"	"	"	"	"	1
	$\infty 2$	120	"	"	"	"	"	1
	$\infty 3$	130?	"	"	"	"	"	3
	$\infty 4$	140	"	"	"	"	"	1
q	$\infty 8$	180	"	"	"	"	"	2
i	01	011	"	"	"	"	"	1

	10	101	Samson Vein, Andreasberg, Harz, Ger.						1
	20	201	"	"	"	"	"		1
	—10	$\bar{1}01$	"	"	"	"	"		1
	—$\frac{2}{3}$0	$\bar{2}03$	"	"	"	"	"		1
p	1	111	"	"	"	"	"		3
π	—1	$\bar{1}11$	"	"	"	"	"		1
	—1$\frac{1}{2}$	$\bar{2}12$	"	"	"	"	"		1
	—$\frac{4}{3}$ $\frac{7}{3}$	$\bar{4}73$	"	"	"	"	"		2
α	$\frac{1}{6}$ $\frac{7}{3}$	1.14.6	"	"	"	"	"		2

1.—W. Bruhns, 1911, Abh. d. naturh. Ges. Hannover, p. 2.
2.—F. Slavic, 1911, Abh. d. böhm. Akad., XVI, No. 20, p. 9.
3.—F. Kolbeck and V. Goldschmidt, 1912, Zeitschr. f. Kryst., L, p. 455.

Sartorite

$a:b:c = 1.27552:1:1.19487 \quad \beta = 77° 48'$

c	0	001	Binnenthal, Switzerland		1
a	∞0	100	"	"	1
b	0∞	010	"	"	1
	20∞	20.1.0	"	"	1
	$\frac{1}{2}\frac{1}{1}$∞	11.2.0	"	"	1
	5∞	510	"	"	1
	$\frac{9}{2}$∞	920	"	"	1
	4∞	410	"	"	1
	$\frac{7}{2}$∞	720	"	"	1
	3∞	310	"	"	1
	$\frac{1}{4}\frac{1}{1}$∞	11.4.0	"	"	1
	$\frac{5}{2}$∞	520	"	"	1
	$\frac{9}{4}$∞	940	"	"	1
	$\frac{1}{5}\frac{1}{1}$∞	11.5.0	"	"	1
	2∞	210	"	"	1
	$\frac{1}{7}\frac{1}{1}$∞	11.7.0	"	"	1
	$\frac{3}{2}$∞	320	"	"	1
	$\frac{4}{3}$∞	430	"	"	1
	$\frac{5}{4}$∞	540	"	"	1
	∞	110	"	"	1
	∞2	120	"	"	1
	∞3	130	"	"	1
	∞4	140	"	"	1
	∞ $\frac{3}{2}\frac{1}{2}$	2.13.0	"	"	1
α	0$\frac{2}{3}$	023	"	"	1

κ	$0\frac{4}{5}$	045	Binnenthal, Switzerland		1
i	01	011	"	"	1
y	$0\frac{6}{5}$	065	"	"	1
l	$0\frac{8}{5}$	085	"	"	1
w	04	041	"	"	1
	40	401	"	"	1
	$\frac{4}{3}0$	403	"	"	1
	$\frac{7}{6}0$	706	"	"	1
	10	101	"	"	1
	$\frac{11}{12}0$	11.0.12	"	"	1
	$\frac{3}{4}0$	304	"	"	1
	$\frac{2}{7}0$	207	"	"	1
	$-\frac{2}{7}0$	$\bar{2}07$	"	"	1
	$-\frac{4}{7}0$	$\bar{4}07$	"	"	1
	$-\frac{2}{3}0$	$\bar{2}03$	"	"	1
	$-\frac{7}{10}0$	$\bar{7}.0.10$	"	"	1
	$-\frac{19}{20}0$	$\bar{19}.0.20$	"	"	1
	-10	$\bar{1}01$	"	"	1
	$-\frac{5}{4}0$	$\bar{5}04$	"	"	1
	$-\frac{4}{3}0$	$\bar{4}03$	"	"	1
	$-\frac{3}{2}0$	$\bar{3}02$	"	"	1
	$-\frac{8}{5}0$	$\bar{8}05$	"	"	1
	$-\frac{9}{5}0$	905	"	"	1
	-20	$\bar{2}01$	"	"	1
	$-\frac{5}{2}0$	$\bar{5}02$	"	"	1
	$-\frac{8}{3}0$	$\bar{8}03$	"	"	1
	-40	$\bar{4}01$	"	"	1
	$-\frac{21}{5}0$	$\bar{21}.0.5$	"	"	1
	$-\frac{9}{2}0$	$\bar{9}02$	"	"	1
	-80	$\bar{8}01$	"	"	1
	-90	$\bar{9}01$	"	"	1
ρ	$\frac{1}{3}$	113	"	"	1
Δ	$\frac{4}{5}$	445	"	"	1
r	1	111	"	"	1
m	$\frac{4}{3}$	443	"	"	1
z	2	221	"	"	1
o	4	441	"	"	1
e	-1	$\bar{1}11$	"	"	1
γ	-4	$\bar{4}41$	"	"	1
p	$\frac{1}{2}1$	122	"	"	1

n	$\frac{3}{2}1$	322	Binnenthal, Switzerland		1
v	21	211	"	"	1
V	$\frac{7}{2}1$	722	"	"	1
N	41	411	"	"	1
C	12.1	12.1.1	"	"	1
δ	$-\frac{1}{6}1$	$\bar{1}66$	"	"	1
h	$-\frac{1}{2}1$	$\bar{1}22$	"	"	1
H	$-\frac{7}{9}1$	$\bar{7}99$	"	"	1
τ	$-\frac{3}{2}1$	$\bar{3}22$	"	"	1
x	—21	$\bar{2}11$	"	"	1
π	$-\frac{7}{2}1$	$\bar{7}22$	"	"	1
η	—61	$\bar{6}11$	"	"	1
β	—12	$\bar{1}21$	"	"	1
A	$\frac{5}{8}\ \frac{5}{4}$	5.10.8	"	"	1
μ	$\frac{2}{3}\ \frac{4}{3}$	243	"	"	1
q	24	241	"	"	1
R	$-\frac{4}{3}\ \frac{8}{3}$	$\bar{4}83$	"	"	1
v	—24	$\bar{2}41$	"	"	1
ϵ	$-\frac{2}{5}\ \frac{4}{5}$	$\bar{2}45$	"	"	1
g	$-\frac{2}{3}\ \frac{4}{3}$	$\bar{2}43$	"	"	1
u	$-\frac{1}{3}\ \frac{2}{3}$	$\bar{1}23$	"	"	1
σ	$\frac{6}{5}\ \frac{4}{5}$	645	"	"	1
s	$2\frac{4}{3}$	643	"	"	1
t	32	321	"	"	1
D	—64	$\bar{6}41$	"	"	1
Y	$7\frac{1}{3}\frac{4}{3}$	21.14.3	"	"	1

1.—C. O. Trechmann, 1907, Min. Mag., XIV, p. 212.

Scheelite

a: *c* = 1:1.53798

ν	$\frac{4}{7}0$	407?	Traversella, Italy		1
λ	$\frac{5}{7}0$	507	"	"	1
u	30	301			3
s	$\frac{2}{7}$	227	Traversella, Italy		1
μ	$\frac{3}{8}$	338	"	"	1
	$\frac{8}{5}$	885	"	"	2
	$1\frac{3}{2}$	232	"	"	2
	$1\frac{2}{3}$	323?	"	"	2
	$\frac{7}{4}\ \frac{1}{4}$	714	"	"	2
	$\frac{7}{5}\ \frac{3}{5}$	735	"	"	2

$\frac{7}{6}\,\frac{5}{6}$	756	Traversella, Italy	2
$\frac{2}{11}\,\frac{1}{11}$	21.1.11?	" "	2

1.—F. Zambonini, 1906, Rend. Accad. Linc., (5) XV, p. 558.
2.— L. Colomba, 1906, Rend. Accad. Linc., (5) XV, p. 281.
3.—P. Berberich, 1914, Jahrb. f. Berg.-u. Hutt. Sach., p. 48.

Schizolite

$a:b:c = 1.10613:1:1.98629 \quad \alpha = 90°\ 11' \quad \beta = 94°\ 46' \quad \gamma = 103°\ 7'$

c	0	001	Julianehaab, Greenland	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
o	$\frac{5}{3}\infty$	530	" "	1
m	∞	110	" "	1
P	$\infty\frac{3}{2}$	230	" "	1
M	$-\infty$	$1\bar{1}0$	" "	1
l	$-\infty 2$	$1\bar{2}0$	" "	1
r	$-\frac{1}{2}0$	$\bar{1}02$	" "	1
n	-10	$\bar{1}01$	" "	1
s	-20	$\bar{2}01$	" "	1
e	$\bar{1}1$	$\bar{1}11$	" "	1
g	$\bar{1}\bar{1}$	$\bar{1}\bar{1}1$	" "	1
f	$\bar{1}4$	$\bar{1}41$	" "	1

1.—O. B. Böggild, 1903, Medd. om Grönland, XXVI, p. 93.

Scolecite

5∞	510	1
$\infty\frac{7}{4}$	570	1
4	441	1
3	331	1
$\frac{1}{5}^{2}$	12.12.5	1
-5	$\bar{5}51$	1
$1\frac{7}{4}$	474	1

1.—G. Flink, 1888, Bihang. k. Ver. Akad. Handl., (2) XIII, p. 8.

Scorodite

f	01	011	Lölling, Carinthia, Austria	1

1.—K. Busz, 1892, Zeitschr. f. Kryst., XX, p. 555.

Seligmanite

$a:b:c = 0.92332:1:0.87338$

c	0	001	Binnenthal, Switzerland[1]		1
a	$\infty 0$	100	"	"	1
b	0∞	010	"	"	1
E	6∞	610	"	"	2
q	5∞	510	"	"	1
A	4∞	410	"	"	1
η	3∞	310	"	"	2
e	2∞	210	"	"	1
l	$\frac{3}{2}\infty$	320	"	"	2
k	$\frac{5}{4}\infty$	540	"	"	3
m	∞	110	"	"	1
μ	$\infty\frac{6}{5}$	560	"	"	3
ψ	$\infty\frac{5}{4}$	450	"	"	3
f	$\infty 2$	120	"	"	1
i	$\infty 3$	130	"	"	1
Φ	$\infty 4$	140	"	"	3
α	$\infty 6$	160	"	"	3
Θ	$\infty 8$	180	"	"	3
x	$0\frac{1}{3}$	013	"	"	1
	$0\frac{2}{5}$	025	"	"	2
n	01	011	"	"	1
z	02	021	"	"	1
Σ	03	031	"	"	1
F	06	061	"	"	2
B	07	071	"	"	1
Δ	$\frac{1}{5}0$	105	"	"	2
t	$\frac{1}{4}0$	104	"	"	2
ϵ	$\frac{1}{3}0$	103	"	"	2
x	$\frac{1}{2}0$	102	"	"	2
h	$\frac{2}{3}0$	203	"	"	2
	10	101	"	"	1
I	20	201	"	"	2
H	$\frac{7}{3}0$	703	"	"	2
G	60	601	"	"	2
	$\frac{2}{9}$	229	"	"	2
φ	$\frac{1}{3}$	113	"	"	2

[1]Legenbach Quarry, Binnenthal, Switzerland.

u	$\frac{1}{2}$	112	Binnenthal, Switzerland[1]		1
y	1	111	"	"	1
	3	331	"	"	2
	4	441	"	"	2
β	18	181	"	"	3
K	16	161	"	"	2
L	13	131	"	"	2
ρ	12	121	"	"	1
N	$1\frac{2}{3}$	323	"	"	2
S	$1\frac{1}{2}$	212	"	"	2
O	$1\frac{1}{3}$	313	"	"	2
M	$\frac{2}{3}1$	233	"	"	2
D	$\frac{3}{2}1$	322	"	"	2
R	$\frac{5}{3}1$	533	"	"	2
v	21	211	"	"	1
Q	$\frac{7}{3}1$	733	"	"	2
C	31	311	"	"	1
P	61	611	"	"	2
O	$\frac{1}{2}5$	1.10.2	"	"	1
Z	26	261	"	"	2
ξ	34	341	"	"	3
ζ	45	451	"	"	3
λ	78	781	"	"	3
J	65	651	"	"	3
γ	54	541	"	"	3
π	$\frac{9}{2}\frac{7}{2}$	972	"	"	3
W	43	431	"	"	1
δ	$\frac{7}{2}\frac{5}{2}$	752	"	"	3
i	$\frac{2}{3}\frac{1}{3}$	213	"	"	1
Y	$\frac{3}{2}\frac{1}{2}$	312	"	"	2
U	$\frac{4}{3}\frac{1}{3}$	413	"	"	2
X	$\frac{7}{3}\frac{1}{2}$	14.3.6	"	"	2
T	$2\frac{1}{3}$	613	"	"	2
S	$\frac{7}{3}\frac{1}{3}$	713	"	"	2
V	$6\frac{1}{2}$	12.1.2	"	"	2

1.—H. Baumhauer, 1901, Ber. Ak. Berlin, p. 110.
2.—R. H. Solly, 1903, Min. Mag., XIII, p. 336; 1906, idem., XIV, p. 184.
3.—R. H. Solly, 1912, Min. Mag., XVI, p. 282.

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[1]Legenbach Quarry, Binnenthal, Switzerland.

Senaite

Hexagonal Trirhombohedral $a:c=1:0.997$

c	0	0001	Diamentia, Minas Geraes, Brazil	1
r	10	$10\bar{1}1$	" " " "	1
s	20	$20\bar{2}1$	" " " "	1
z	40	$40\bar{4}1$	" " " "	1

1.—E. Hussak and G. T. Prior, 1898, Min. Mag., XII, p. 30.

Siderite

	$\frac{1}{2}0$	$10\bar{1}2$	Pontgibaud, Puy-de-Dôme, France	2
	$\frac{3}{4}0$	$30\bar{3}4$	Chateauneuf-sur-les-Baines, Puy-de-Dôme, France	2
l	$\frac{7}{5}0$	$70\bar{7}5$	Frostburg, Md.	3
k	$\frac{5}{2}0$	$50\bar{5}2$	" "	3
l	30	$30\bar{3}1$	Cornwall, England	4
	$-\frac{3}{2}0$	$03\bar{3}2$	Chateauneuf-sur-les-Baines, Puy-de-Dôme, France	2
Δ	$-\frac{7}{2}0$	$07\bar{7}2$	Cornwall, England	4
y	32	$32\bar{5}1$	Frostburg, Md.	3
	-42	$24\bar{6}1$	Algeria	1

1.—G. Cesáro, 1891, Ann. Soc. Géol. Belg., XVIII, Bull, p. 82.
2.—F. Gonnard, 1895, Bull. Soc. fr. Min., XVIII, p. 382.
3.—W. T. Schaller, 1906, Amer. Journ. Sci., XXI, p. 364.
4.—M. Henglein, 1907, Zeitschr. f. Kryst., XLIII, p. 575.

Sillimanite

$a:b:c=0.9696:1:0.7046$

q	$0\frac{5}{2}$	052	Chester, Conn.	1

1.—E. Taubert, 1906, Centralbl. f. Min., p. 372.

Skutterudite

e	2∞	210	Turtmannthal, Switzerland	1

1.—L. Staudenmair, 1892, Zeitschr. f. Kryst., XX, p. 468.

Smithite

$a:b:c=0.9696:1:0.7046$

c	0	001	Binnenthal, Switzerland[1]	1
a	$\infty 0$	100	" "	1
l	$\frac{3}{2}\infty$	320	" "	2

[1]Legenbach Quarry, Binnenthal, Switzerland.

	01	011	Binnenthal, Switzerland[1]	1
h	$\frac{1}{2}0$	102	" "	2
e	10	101	" "	1
d	—10	$\bar{1}01$	" "	1
p	1	111	" "	1
P	—1	$\bar{1}11$	" "	1
	$\frac{3}{5}1$	355	" "	1
	$\frac{3}{2}1$	322	" "	1
q	21	211	" "	1
r	31	311	" "	1
	41	411	" "	1
Q	—21	$\bar{2}11$	" "	1
R	—31	$\bar{3}11$	" "	2
	—41	$\bar{4}11$	" "	1
	—51	$\bar{5}11$	" "	1
	$-1\frac{1}{2}$	$\bar{2}12$	" "	1

1.—R. H. Solly, 1905, Min. Mag., XIV, p. 72.
2.—G. F. Herbert-Smith and G. T. Prior, 1907, Min. Mag., XIV, p. 293.

Smithsonite

$-\frac{1}{5}0$	$01\bar{1}5$	San Amiceto, Almaden, Spain	1

1.—H. Buttgenbach, 1906, Bull. Soc. fr. Min., XXIX, p. 190.

Sodalite

32	321	Vesuvius, Italy	1

1.—F. Zambonini, 1906, Rend. Accad. Linc., XV, p. 235.

Sousmansite

Tetragonal $a:c=1:0.7672$

$\infty 0$	100	Montebras, Creuse, France	1
1	111	" " "	1

1.—A. Lacroix, 1910, Min. de France, IV, p. 541.

Spencerite

$a:b:c=1.0125:1:1.0643 \quad \beta=63° 13'$

0	001	Salmo, British Columbia	1
$\infty 0$	100	" " "	1
0∞	010	" " "	1

[1]Lengenbach Quarry, Binnenthal, Switzerland.

$\frac{5}{2}\infty$	520	Salmo, British Columbia				1
∞	110	"	"	"		1
$\infty\frac{3}{2}$	230	"	"	"		1
$\infty 2$	120	"	"	"		1
$0\frac{2}{3}$	023	"	"	"		1
02	021	"	"	"		1
$-\frac{1}{4}0$	$\bar{1}04$	"	"	"		1
$-\frac{1}{2}0$	$\bar{1}02$	"	"	"		1
$-\frac{3}{4}0$	$\bar{3}04$	"	"	"		1
-10	$\bar{1}01$	"	"	"		1
-20	$\bar{2}01$	"	"	"		1
-1	$\bar{1}11$	"	"	"		1
-2	$\bar{2}21$	"	"	"		1
12	121	"	"	"		1
-12	$\bar{1}21$	"	"	"		1
$\frac{1}{2}\frac{2}{3}$	346	"	"	"		1
-24	$\bar{2}41$	"	"	"		1

1.—T. L. Walker, 1917, Journ. Wash. Acad. Sci., VII, p. 456.

Sperrylite

Isometric Pyritohedral

a	$\infty 0$	100	Vermillion Mine, Ontario, Can.				1
a	3∞	310	"	"	"	"	3
g	$\frac{5}{2}\infty$	520	"	"	"	"	3
e	2∞	210	"	"	"	"	1
h	$\frac{5}{3}\infty$	530	"	"	"	"	3
b	$\frac{3}{2}\infty$	320	"	"	"	"	3
d	∞	110	"	"	"	"	1
o	1	111	"	"	"	"	1
u	2	221	"	"	"	"	3
k	41	411	"	"	"	"	3
m	31	311	"	"	"	"	3
q	21	211	"	"	"	"	3
B	$\frac{5}{3}1$	533	"	"	"	"	3
A	$5\frac{5}{2}$	10.5.2?	"	"	"	"	2
D	$3\frac{3}{2}$	632?	"	"	"	"	3
ψ	42	421	"	"	"	"	3
x	32	321	"	"	"	"	3
z	53	531?	"	"	"	"	3

1.—S. L. Penfield, 1889, Amer. Journ. Sci., XXXVII, p. 71.
2.—T. L. Walker, 1896, Amer. Journ. Sci., I, p. 110.
3.—V. Goldschmidt and W. Nicol, 1903, Amer. Journ. Sci., XV, p. 450.

Sphalerite

	10	10.10.1	Kis-Almás, Hungary	3
y	4	441	Mies, Bohemia	6
	$\frac{7}{5}$	775	Galena, Ill.	2
e.[2]	$-\frac{5}{3}$	$5\bar{5}3$	Harz Mts., Germany	4
σ	$\frac{8}{3}1$	833?	Galena, Kansas	5
k	$-\frac{17}{6}1$	$17.\bar{6}.6$	Joplin, Mo.	7
t[2]	$-\frac{7}{3}1$	$7\bar{3}3$	Harz Mts., Germany	4
	$-3\frac{3}{2}$	$6\bar{3}2$	Traversella, Italy	8
	$-\frac{1}{2}\frac{1}{6}$	$3\bar{1}6$	Binnenthal, Switzerland	1
	$-\frac{3}{4}\frac{1}{8}$	$6\bar{1}8$	" "	1

1.—G. Cesáro, 1893, Bull. Ac. Belg., XXV, p. 88.
2.—W. H. Hobbs, 1895, Bull. Univ. Wis., I, p. 134.
3.—A. Franzenau, 1896, Zeitscrh. f. Kryst., XXVII, p. 95.
4.—O. Leudecke, 1896, Min. d. Harzes, p. 53.
5.—A. F. Rogers, 1900, Amer. Journ. Sci., IX, p. 134.
6.—A. Mühlhauser, 1901, Min. u. petro. Mitth., XX, p. 83.
7.—A. F. Rogers, 1904, Univ. Geol. Surv. Kansas, VIII, p. 453.
8.—L. Colomba, 1906, Rend. Accad. Linc., XV, p. 640.

Spodiosite

a: b: c = 0.8944:1:1.5836

c	0	001	Nordmark, Sweden	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1
m	∞	110	" "	1
e	02	021	" "	1
d	$\frac{1}{2}0$	102	" "	1
p	1	111	" "	1
q	$\frac{1}{2}\frac{5}{4}$	254?	" "	1
r	$2\frac{5}{4}$	854?	" "	1

1.—G. Nordenskiöld, 1893, Geol. Fören. Förh., XV, p. 460.

Spodumene

A	$\infty\frac{5}{3}$	350	Pala, San Diego Co., Calif.	1
	1	111	Rincon, San Diego Co., Calif.	2

1.—W. T. Schaller, 1903, Univ. Calif. Bull. Geol., III, p. 265.
2.—A. F. Rogers, 1910, School of Mines Quar., XXXI, p. 208.
*3.—F. Zambonini, 1909, Zeitschr. f. Kryst., XLVI, p. 1.

Stannite

Tetragonal Sphenohedral $a:c=1:0.9823\pm$

c	0	001	Bolivia	1
a	$\infty 0$	100	"	1
m	∞	110	"	1
e	10	101	"	1
z	20	201	"	1
d	$\frac{1}{4}$	114	"	1
n	$\frac{1}{2}$	112	"	1
p	1	111	"	1
t	2	221	"	1
$-n$	$-\frac{1}{2}$	$1\bar{1}2$	"	1
$-p$	-1	$1\bar{1}1$	"	1
u	$\frac{4}{3}\ \frac{2}{3}$	423	"	1

1.—J. L. Spencer, 1901, Min. Mag., XIII, p. 54.

Steenstrupine

Hexagonal Rhombohedral $a:c=1:1.0842$

c	0	0001	Kangerdlaarsuk	Greenland	1
a	∞	$11\bar{2}0$	"	"	1
ρ	$\frac{5}{9}0$	$50\bar{5}9$	"	"	1
r	10	$10\bar{1}1$	"	"	1
z	40	$40\bar{4}1$	"	"	1
ϵ	$-\frac{1}{3}0$	$01\bar{1}3$	"	"	1
e	$-\frac{1}{2}0$	$01\bar{1}2$	"	"	1
f	$-\frac{4}{5}0$	$04\bar{4}5$	"	"	1
d	-20	$02\bar{2}1$	"	"	1
ξ	-80	$08\bar{8}1$	"	"	1

1.—J. C. Moberg, 1898, Zeitschr. f. Kryst., XXIX, p. 386.

Stellerite

$a:b:c=0.98:1:0.76\ \pm$

a	$\infty 0$	100	Copper Island, Commander Islands Kamscatka	1
b	0∞	010	Copper Island, Commander Islands, Kamscatka	1
l	2∞	210	Copper Island, Commander Islands, Kamscatka	1
m	∞	110	Copper Island, Commander Islands, Kamscatka	1

o	1	111	Copper Island, Commander Islands, Kamscatka	1

1.—J. Morozewics, 1909, Bull. Ac. Sc. Cracovic, p. 344.

Stelznerite

a: b: c = 0.50368:1:0.70585

c	0	001	Remolinos, Valliner, Chile	1
b	0∞	010	" " "	1
m	∞	110	" " "	1
o	01	011	" " "	1
p	1	111	" " "	1

1.—A. Arzuni and K. Thaddéeff, 1899, Zeitschr. f. Kryst., XXXI, p. 229.

Stephanite

	5∞	510	Sarrabus, Sardinia 1
	∞$\frac{4}{3}$	340	Přibram, Bohemia 4
	∞$\frac{3}{2}$	230	Sarrabus, Sardinia 1
	∞$\frac{10}{3}$	3.10.0	Přibram, Bohemia 4
	∞4	140	" " 4
	∞6	160	" " 4
	∞15	1.15.0	Guanajuato, Mexico 6
	0$\frac{2}{7}$	027	Sarrabus, Sardinia 5
	0$\frac{3}{8}$	038	Sarrabus, Sardinia and Pribram, Bohemia 4+5
	0$\frac{5}{11}$	0.5.11	Sarrabus, Sardinia 1
	0$\frac{3}{5}$	035	Přibram, Bohemia 5
	0$\frac{5}{6}$	056	" " 5
	0$\frac{8}{7}$	087	" " 4
	04	041	Sarrabus, Sardinia 5
	06	061	" " 5
	$\frac{1}{7}$	117	Sonora, Mexico 6
	$\frac{1}{6}$	116	" " 6
	$\frac{10}{13}$	10.10.13	Chile 3
	$\frac{7}{6}$	776	Sarrabus, Sardinia 5
	$\frac{5}{3}$	553	Přibram, Bohemia 4
	$\frac{8}{5}$	885	Sarrabus, Sardinia 5
	$\frac{11}{5}$	11.11.5	Přibram, Bohemia 4
	$\frac{8}{3}$	883	" " 4
N	$\frac{5}{2}$	552	" " 2
	$\frac{7}{2}$	772	Sarrabus, Sardinia 5

r	4	441	Přibram, Bohemia	2
	5	551	Sarrabus, Sardinia	5
	$\frac{1}{3}\frac{7}{}$	17.17.3	Přibram, Bohemia	4
	6	661	Guanajuato, Mexico	6
	$1\frac{1}{8}$	818	Sarrabus, Sardinia	1
	14	141	" "	1
	16	161	" "	1
	$\frac{1}{4}\frac{3}{}1$	13.4.4	" "	1
	$\frac{1}{5}\frac{8}{}1$	18.5.5	" "	1
	51	511	Chile	3
	$\frac{3}{7}\ \frac{2}{7}$	3.27.7	Sarrabus, Sardinia	5
	2.10	2.10.1	" "	1
	$\frac{1}{3\,0}\ \frac{1}{6}$	1.5.30	" "	5
	$\frac{1}{2\,3}\ \frac{4}{2\,3}$	1.4.23	" "	5
	$\frac{1}{2\,0}\ \frac{1}{5}$	1.4.20	" "	5
	$\frac{5}{9}\ \frac{1}{9}$	5.17.9	Přibram, Bohemia	4
t_3	$\frac{1}{2}\ \frac{3}{1\,6}$	8.13.16?	" "	2
	$\frac{1}{1\,9}\ \frac{3}{1\,9}$	1.3.19	" "	5
	$\frac{1}{1\,7}\ \frac{3}{1\,7}$	1.3.17	" "	5
N	$\frac{3}{2}5$	3.10.2	Guanajuato, Mexico	6
	25	251	Přibram, Bohemia	7
	$\frac{3}{2}\ \frac{7}{2}$	372	Sarrabus, Sardinia	1
	$\frac{4}{5}\ \frac{8}{5}$	485	" "	5
	$\frac{7}{9}\ \frac{1}{9}$	7.11.9	" "	1
Z	9.11	9.11.1	Guanajuato, Mexico	6
X	57	571	" "	6
h_2	$\frac{1}{2}\ \frac{3}{1\,8}$	9.13.18?	Přibram, Bohemia	2

1.—E. Artini, 1891, Giorn. d. Min., II, p. 241.
2.—V. Nejdl, 1895, Ber. böhm. Ges., No. 6.
3.—L. J. Spencer, 1897, Min. Mag., XI, p. 192.
4.—F. Slavic, 1901, Abh. d. böhm. Akad., XVI.
5.—G. d'Achiardi, 1901, Att. Soc. Tosc., Mem., XVIII, p. 96.
6.—H. Ungemach, 1910, Bull. Soc. fr. Min., XXXIII.
7.—H. Ungemach, 1912, Ann. Soc. Géol. Belg., Mém., XXXIX, p. 5.

Stibiotantalite

Orthorhombic Hemimorphic $a:b:c = 0.8879:1:2.1299$

0	001	Mesa Grande, San Diego Co., Calif.	1
$0\,\infty$	010	" " " " " "	2
∞	110	" " " " " "	1
$0\frac{1}{2}$	012	" " " " " "	1

	01	011	Mesa Grande, San Diego Co., Calif.	2
	02	021	" " " " " "	1
	$\frac{1}{9}0$	109	" " " " " "	2
	$\frac{1}{7}0$	107	" " " " " "	2
	$\frac{1}{5}0$	105	" " " " " "	2
	$\frac{1}{3}0$	103	" " " " " "	1
	10	101	" " " " " "	1
	$\frac{1}{7}$	117	" " " " " "	2
	1	111	" " " " " "	1
	$\frac{1}{3}1$	133	" " " " " "	2
	$\frac{1}{3}\frac{2}{3}$	123	" " " " " "	2

1.—S. L. Penfield and W. E. Ford, 1906, Amer. Journ. Sci., XXII, p. 6.
2.—H. Ungemach, 1909, Bull. Soc. fr. Min., XXXII, p. 92.

Stibnite

	$\infty\frac{8}{3}$	308	Val de Ville, Alsace, France	2
l	$\infty 8$	180	" " "	2
P	$\frac{2}{1}\frac{2}{1}$	2.2.11	Iyo, Japan	4
Ψ_1	$\frac{4}{2}\frac{1}{7}\frac{7}{7}$	4.17.27	Přibram, Bohemia	3
Γ_1	$\frac{1}{3}\frac{1}{2}$	236	" "	3
$\mathfrak{x}$	$\frac{5}{4}\frac{5}{3}$	15.20.12	" "	3
$\mathfrak{H}$	$\frac{1}{1}\frac{1}{2}\frac{1}{6}$	1.2.12	" "	3
$\mathfrak{r}$	$\frac{5}{3}2$	563	Schlaining, Eisenburg, Hungary	1
$\mathfrak{w}$	$4\frac{1}{3}^{9}$	12.19.3	" " "	1
$\mathfrak{U}$	$\frac{2}{3}\frac{3}{5}$	10.9.15	" " "	1
$\mathfrak{s}$	$4\frac{1}{1}\frac{9}{0}$	40.19.10	" " "	1
	$\frac{1}{2}\frac{1}{2}\frac{5}{2}$	11.5.2	Iyo, Japan	3

1.—A. Schmidt, 1898, Zeitschr. f. Kryst., XXIX.
2.—H. Ungemach, 1906, Bull. Soc. fr. Min., XXIX, p. 264.
3.—Z. Jarös, 1907, Abh. d. böhm. Akad., XVI, No. 14.
4.—G. Aminoff, 1919, Ark. Kemi. Min. Geol., VII, No. 17, p. 6..

Stokesite

$a:b:c = 0.3462:1:0.8037$

c	0	001	St. Just, Cornwall, England	1
b	0∞	010	" " "	1
m	∞	110	" " "	1
s	$1\frac{6}{5}$	565	" " "	1
v	12	121	" " "	1
t	$\frac{1}{2}1$	122	" " "	1

1.—A. Hutchinson, 1900, Min. Mag., XII, p. 274.

STOLZITE

a	$\infty 0$	100	Broken Hill, N. S. Wales, Australia	2
	$\infty 2$	120	Laudville, Mass.	1
	$\infty 3$	130	" "	1
Ω	$\frac{1}{10}0$	1.0.10	Broken Hill, N. S. Wales, Australia	2
ω	$\frac{1}{9}0$	109	" " " "	2
τ	$\frac{1}{8}0$	103	" " " "	2
o	$\frac{1}{2}0$	102	" " " "	2
η	$\frac{2}{5}0$	203	" " " "	2
h	$\frac{3}{4}0$	304	" " " "	2
ϵ	20	201	" " " "	2
	$\frac{1}{9}$	119	Ozieri, Sardinia	3
	$\frac{1}{7}$	117	" "	3
	$\frac{1}{5}$	115	" "	3
	$\frac{1}{3}$	113	" "	3
	$1\frac{1}{3}$	131	Laudville, Mass.	1
	$\frac{2}{3}1$	233	Ozieri, Sardinia	3
	$\frac{3}{4}1$	344?	" "	3
	$\frac{4}{5}1$	455?	" "	3
	$\frac{8}{9}1$	899?	" "	3
	$\frac{3}{2}2$	243	Laudville, Mass.	1

1.—B. K. EMERSON, 1895, U. S. Geol. Surv., Bull. CXXVI, p. 163.
2.—C. HLAWATSCH, 1897, Zeitschr. f. Kryst., XXIX, p. 130.
3.—E. ARTINI, 1905, Rend. Inst. Lomb. Milan, XXXVIII, p. 373.

STRONTIANITE

v	03	031	Althalen, Westphalia, Germany	2
f	05	051	Münsterland, Westphalia, Ger.	3
μ	07	071	" " "	3
ν	0.11	0.11.1	" " "	3
n	$\frac{1}{5}$	115	Brixlegg, Tyrol	1
r	$\frac{11}{4}$	11.11.4	Münsterland, Westphalia, Ger.	3
d	6	661	Brixlegg, Tyrol	1
θ	10	10.10.1	Münsterland, Westphalia, Ger.	3
π	24	24.24.1	" " "	3
Ψ	36	36.36.1	" " "	3

1.—A. GATHREIN, 1888, Zeitschr. f. Kryst., XIV, p. 366.
2.—C. VRBA, 1889, Zeitschr. f. Kryst., XV, p. 449.
3.—J. BEYKIRCH, 1901, Neues Jahrb. f. Min., Beil.-B., p XIII, p. 389.

Strüverite

Tetragonal $a:c = 1:0.6456$

a	$\infty 0$	100	Val Vigesso, Piedmont, Italy	1
m	∞	110	" " "	1
s	1	111	" " "	1

1.—G. T. Prior and F. Zambonini, 1908, Min. Mag., XV, p. 78.

Stylotypite

$a:b:c = 1.9202:1:1.0355 \quad \beta = 90° \pm$

a	$\infty 0$	100	"Candalosa Costrovirroyna," Peru	1
μ	3∞	310	" " "	1
n	2∞	210	" " "	1
m	∞	110	" " "	1
d	$0\frac{3}{2}$	032	" " "	1
r	10	101	" " "	1
t	$\frac{3}{2}0$	302	" " "	1
s	40	401	" " "	1
x	1	111	" " "	1
y	$\frac{3}{2}$	332	" " "	1
q	$1\frac{1}{3}$	313	" " "	1
o	31	311	" " "	1

1.—S. Stevanovic, 1902, Zeitschr. f. Kryst., XXXVII, p. 235.

Sulphoborate

$a:b:c = 0.6191:1:0.8100$

c	0	001	Westeregeln, Saxony, Germany	1
b	0∞	010	" " "	1
m	∞	110	" " "	1
r	10	101	" " "	1
o	1	111	" " "	1

1.—H. Bücking, 1893, Ber. Ak. Berlin, p. 967.

Sulphur

	$0\frac{4}{3}$	043	Corphalie, Belgium	4
	$\frac{1}{2}0$	102	" "	4
φ	$\frac{3}{5}0$	305	Buggeru, Sardinia	3
	20	201	Corphalie, Belgium	4
	$\frac{1}{6}$	116	" "	4
	$\frac{3}{16}$	3.3.16	" "	4

	$\frac{2}{9}$	229?	Corphalie, Belgium	4
	$\frac{2}{7}$	227	" "	4
η	$\frac{5}{3}$	553	Bassick, Custer Co., Colo.	1
f	15	151	Roisdorf, (Bonn), Germany	1
λ	$\frac{1}{5}1$	155	Buggeru, Sardinia	3
k_0	$\frac{1}{2}1$	122	Allchar, Macedonia	2
μ	$\frac{1}{3}$ $\frac{1}{9}$	319	Buggeru, Sardinia	3

1.—K. Busz, 1892, Zeitschr. f. Kryst., XX, p. 529.
2.—A. Pelikan, 1892, Min. u. petro. Mitth., XII, p. 344.
3.—F. Millosevich, 1898, Riv. Min. Ital., XXI, p. 43.
4.—H. Buttgenbach, 1898, Ann. Soc. Géol. Belg., XXV, p. 73.

Sylvanite

U	6∞	610	Nagyag, Hungary	4
L	$\frac{3}{2}\infty$	320	" "	4
T	$\frac{1}{3}0$	103	Cripple Creek, Colo.	3
H_1	$\frac{1}{2}0$	102	" " "	3
q	$\frac{2}{3}0$	203	" " " (Goldschmidtite)	1
x	$\frac{4}{3}0$	403	" " " "	1
L	$-\frac{2}{3}0$	$\bar{2}03$	" " "	3
G	$-\frac{3}{2}0$	$\bar{3}02$	Nagyag, Hungary	4
l	16	161	Cripple Creek, Colo. (Goldschmidtite)	1
t	$1\frac{9}{2}$	292	Cripple Creek, Colo. (Goldschmidtite)	1
w	$1\frac{4}{3}$	343	Cripple Creek, Colo.	2
v	$1\frac{2}{5}$	525	" " "	2
η	$\frac{5}{3}$ $\frac{2}{3}$	523	Nagyag, Hungary	4
j	52	521	Cripple Creek, Colo.	2
u	$\frac{7}{3}$ $\frac{2}{3}$	723	" " "	2
T	$-\frac{3}{2}$ $\frac{1}{2}$	$\bar{3}12$	Nagyag, Hungary	4
ϵ	$-\frac{5}{3}$ $\frac{4}{3}$	$\bar{5}43$	" "	4

1.—W. H. Hobbs, 1899, Amer. Journ. Sci., VII, p. 357.
2.—C. Palache, 1900, Amer. Journ. Sci., X, p. 419.
3.—A. J. Moses, 1905, Amer. Journ. Sci., XX, p. 282.
4.—C. Vrba, 1908, Zeitschr. f. Kryst., XLIV, p. 69.

Sylvite

$\frac{4}{3}1$	433	Kalusz, Galicia	1
$\frac{8}{5}1$	855	" "	1
31	311	" "	1

	91	911	Kalusz, Galicia	1
	$2\frac{9}{2}$	492	" "	1
	48	{481	" "	1
	84	{841		
	$2\frac{7}{2}$	{472	" "	1
	$\frac{7}{2}2$	{742		
	23	231	" "	1
	$\frac{5}{3}3$	563	" "	1
	$\frac{7}{2}\,\frac{1}{2}$	721	" "	1
	$\frac{5}{2}\,\frac{3}{2}$	532	" "	1

1.—St. Kreutz, 1912, Zeitschr. f. Kryst., LI, p. 209.

Tainiolite

$a:b:c = 0.5774:1:3.2743 \quad \beta = 90°$

c	0	001	Narsarsuk, Greenland	1
b	0∞	010	" "	1
θ	$0\frac{2}{7}$	027	" "	1
e	$0\frac{2}{3}$	023	" "	1
μ	—1	$\bar{1}11$	" "	1

1.—G. Flink, 1898, Medd. om Grönland, XIV, p. 234; 1901, idem, XXIV, p. 115.

Tantalite

d	$\frac{7}{3}\infty$	730	Black Hills, S. Dak.	2
γ	61	611	Pisek, Bohemia	1
d	31	311	" "	1
w	$\frac{3}{4}1$	344	" "	1
σ	$\frac{1}{3}1$	133	" "	1

1.—C. Vrba, 1889, Zeitschr. f. Kryst., XV, p. 194.
2.—W. P. Blake, 1891, Amer. Journ. Sci., XLI, p. 403.

Tarbuttite

$a:b:c = 0.9583:1:1.3204 \quad \alpha = 102° 37' \quad \beta = 123° 52' \quad \gamma = 87° 25'$

c	0	001	Broken Hill, N. W. Rhodesia	1
a	$\infty 0$	100	" " "	1
b	0∞	010	" " "	1
m	∞	110	" " "	1
n	$-\infty 2$	$\bar{1}20$	" " "	2
l	02	021	" " "	1
p	$0\frac{5}{2}$	052	" " "	2
u	—01	$0\bar{1}1$	" " "	1

h	—02	$0\bar{2}1$	Broken Hill, N. W. Rhodesia	1
f	—10	$\bar{1}01$	" " "	1
s	$-\frac{1}{2}0$	$\bar{1}02$	" " "	1
t	$-\frac{1}{3}0$	$\bar{1}03$	" " "	1
K	—1	$\bar{1}11$?	" " "	2
D	$\frac{1}{5}\ \frac{1}{5}$	$1\bar{1}5$	" " "	2
C	$\frac{4}{5}\ \frac{1}{5}$	$4\bar{4}5$?	" " "	2
G	$\frac{5}{4}\ \frac{5}{4}$	$\bar{5}54$	" " "	2
e	$\bar{2}2$	$\bar{2}21$	" " "	1
y	$\frac{2}{5}\ \frac{2}{5}$	$\bar{2}2\bar{5}$?	" " "	2
L	$\frac{4}{9}\ \frac{4}{9}$	$\bar{4}4\bar{9}$?	" " "	2
x	$\frac{1}{2}\ \frac{1}{2}$	$\bar{1}1\bar{2}$?	" " "	2
d	$\frac{2}{3}\ \frac{2}{3}$	$\bar{2}2\bar{3}$	" " "	1
k	11	$\bar{1}\bar{1}1$	" " "	1
z	$\frac{5}{2}\ \frac{5}{2}$	$\bar{5}5\bar{2}$	" " "	2
o	$1\bar{2}$	$1\bar{2}1$	" " "	1
g	$\bar{2}1$	$\bar{2}11$?	" " "	1
B	$\frac{1}{3}\bar{1}$	$\bar{1}3\bar{3}$	" " "	2
i	$\frac{1}{2}\bar{1}$	$\bar{1}2\bar{2}$	" " "	1
H	$\frac{1}{3}3$	$\bar{1}9\bar{3}$	" " "	2
W	$\frac{3}{2}6$	$\bar{3}.12.\bar{2}$	" " "	2
N	$\bar{2}6$	$\bar{2}6\bar{1}$	" " "	2
P	$\bar{3}2$	$\bar{3}2\bar{1}$	" " "	2
F	$\bar{4}2$	$\bar{4}2\bar{1}$	" " "	2
E	$\frac{3}{4}\bar{2}$	$3\bar{8}\bar{4}$	" " "	2
r	$\frac{2}{3}\ \frac{4}{3}$	$\bar{2}4\bar{3}$	" " "	1
M	$\frac{8}{5}\ \frac{2}{5}$	$\bar{8}\bar{2}5$	" " "	2

1.—L. J. Spencer, 1908, Min. Mag., XV, p. 22.
2.—V. Rosický, 1913, Abh. d. böhm. Akad., No. 35, p. 11.

Tellurite

h	$\frac{3}{2}\infty$	520	Cripple Creek, Colo.	1
l	2∞	210	" " "	1

1.—W. T. Schaller, 1905, U. S. Geol. Surv., Bull., CCLXII, p. 127.

Terlinguaite

$a:b:c = 1.6050:1:2.0245 \quad \beta = 74° 23'$

c	0	001	Terlingua, Texas	1
a	$\infty 0$	100	" "	1
b	0∞	010	" "	1

e	6∞	610	Terlingua, Texas		2
d	$\frac{8}{3}\infty$	830	"	"	2
w	$\frac{5}{2}\infty$	520	"	"	2
δ	2∞	210	"	"	1
B	$\frac{3}{2}\infty$	320	"	"	2
m	∞	110	"	"	1
v	$\infty\frac{3}{2}$	230	"	"	2
j	$\infty 2$	120	"	"	2
l	$0\frac{1}{7}$	017	"	"	2
h	$0\frac{1}{5}$	015	"	"	1
f	$0\frac{1}{3}$	013	"	"	1
b	$0\frac{2}{5}$	025	"	"	2
a	$0\frac{4}{9}$	049	"	"	2
h	$0\frac{1}{2}$	012	"	"	2
g	$0\frac{3}{5}$	035	"	"	2
f	$0\frac{4}{5}$	045	"	"	2
d	01	011	"	"	1
D	03	031	"	"	2
n	$\frac{1}{5}0$	105	"	"	2
o	$\frac{1}{4}0$	104	"	"	2
p	$\frac{1}{3}0$	103	"	"	2
j	$\frac{3}{8}0$	308	"	"	2
t	$\frac{1}{2}0$	102	"	"	1
r	$\frac{2}{3}0$	203	"	"	2
M	$\frac{3}{4}0$	304	"	"	2
y	10	101	"	"	1
s	$\frac{4}{3}0$	403	"	"	2
F	$\frac{5}{3}0$	503	"	"	2
w	30	301	"	"	1
G	40	401	"	"	2
y	90	901	"	"	2
k	12.0	12.0.1	"	"	2
M	$-\frac{1}{7}0$	$\bar{1}07$	"	"	2
L	$-\frac{1}{4}0$	$\bar{1}04$	"	"	2
W	$-\frac{1}{3}0$	$\bar{1}03$	"	"	2
n	$-\frac{1}{2}0$	$\bar{1}02$	"	"	1
x	$-\frac{3}{5}0$	$\bar{3}05$	"	"	2
N	$-\frac{2}{3}0$	$\bar{2}03$	"	"	2
y	$-\frac{3}{4}0$	$\bar{3}04$	"	"	2
R	$-\frac{4}{5}0$	$\bar{4}05$	"	"	2

u	—10	$\bar{1}01$	Terlingua, Texas		1
π	—$\frac{6}{5}$0	$\bar{6}05$	"	"	2
P	—$\frac{4}{3}$0	$\bar{4}03$	"	"	2
Q	—$\frac{3}{2}$0	$\bar{3}02$	"	"	2
$\mathfrak{B}$	—$\frac{5}{3}$0	$\bar{5}03$	"	"	2
x	—20	$\bar{2}01$	"	"	1
$\mathfrak{C}$	—$\frac{5}{2}$0	$\bar{5}02$	"	"	2
z	—30	$\bar{3}01$	"	"	1
S	—40	$\bar{4}01$	"	"	2
θ	—50	$\bar{5}01$	"	"	2
$\mathfrak{z}$	—70	$\bar{7}01$	"	"	2
$\mathfrak{Z}$	—12.0	$\bar{1}\bar{2}.0.1$	"	"	2
λ	$\frac{1}{5}$	115	"	"	1
O	$\frac{1}{3}$	113	"	"	2
$\mathfrak{B}$	$\frac{3}{7}$	337	"	"	2
π	$\frac{1}{2}$	112	"	"	1
k	$\frac{3}{4}$	334	"	"	1
p	1	111	"	"	1
β	—$\frac{1}{5}$	$\bar{1}15$	"	"	1
H	—$\frac{1}{4}$	$\bar{1}14$	"	"	2
ρ	—$\frac{1}{3}$	$\bar{1}13$	"	"	2
Ξ	—$\frac{3}{4}$	$\bar{3}34$	"	"	2
e	—1	$\bar{1}11$	"	"	1
Λ	13	131	"	"	2
θ	12	121	"	"	2
I	—13	$\bar{1}31$	"	"	2
Ω	—12	$\bar{1}21$	"	"	2
a	—1$\frac{1}{3}$	$\bar{3}13$	"	"	1
Υ	—1$\frac{1}{5}$	$\bar{5}15$	"	"	2
$\mathfrak{E}$	$\frac{1}{10}$1	1.10.10	"	"	2
τ	$\frac{1}{8}$1	188	"	"	2
$\mathfrak{H}$	$\frac{1}{6}$1	166	"	"	2
$\mathfrak{q}$	$\frac{1}{5}$1	155	"	"	2
s	$\frac{1}{4}$1	144	"	"	2
ϵ	$\frac{1}{3}$1	133	"	"	2
z	$\frac{1}{2}$1	122	"	"	2
v	$\frac{3}{5}$1	355	"	"	1
Y	$\frac{2}{3}$1	233	"	"	2
$\mathfrak{R}$	$\frac{3}{4}$1	344	"	"	2
r	$\frac{4}{3}$1	433	"	"	1

χ	$\frac{3}{2}1$	322	Terlingua, Texas	2
$\mathfrak{M}$	$\frac{5}{3}1$	533	" "	2
i	21	211	" "	1
s	31	311	" "	1
$\mathfrak{D}$	41	411	" "	2
σ	$-\frac{1}{5}1$	$\bar{1}55$	" "	2
φ	$-\frac{1}{4}1$	$\bar{1}44$	" "	2
x	$-\frac{1}{3}1$	$\bar{1}33$	" "	2
$\mathfrak{L}$	$-\frac{2}{5}1$	$\bar{2}55$	" "	2
ψ	$-\frac{1}{2}1$	$\bar{1}22$	" "	2
ω	$-\frac{3}{5}1$	$\bar{3}55$	" "	2
Δ	$-\frac{2}{3}1$	$\bar{2}33$	" "	2
Γ	$-\frac{3}{4}1$	$\bar{3}44$	" "	2
$\mathfrak{F}$	$-\frac{6}{7}1$	$\bar{6}77$	" "	2
l	$-\frac{4}{3}1$	$\bar{4}33$	" "	1
$\mathfrak{R}$	$-\frac{3}{2}1$	$\bar{3}22$	" "	2
g	-21	$\bar{2}11$	" "	1
$\mathfrak{S}$	$-\frac{5}{2}1$	$\bar{5}22$	" "	2
o	-31	$\bar{3}11$	" "	1
γ	-41	$\bar{4}11$	" "	1
$\mathfrak{c}$	$\frac{3}{7}\ \frac{1}{7}$	317	" "	2
U	$-\frac{3}{11}\ \frac{1}{11}$	$\bar{3}.1.11$	" "	2
V	$-\frac{1}{3}\ \frac{1}{9}$	$\bar{3}19$	" "	2
q	$-\frac{3}{5}\ \frac{1}{5}$	$\bar{3}15$	" "	1
$\mathfrak{T}$	$\frac{1}{2}\ \frac{1}{3}$	326	" "	2
$\mathfrak{P}$	$\frac{3}{8}\ \frac{1}{4}$	328	" "	2
α	$\frac{3}{14}\ \frac{2}{7}$	3.4.14	" "	2
Σ	$\frac{1}{4}\ \frac{1}{2}$	124	" "	2
$\mathfrak{X}$	$\frac{1}{6}\ \frac{1}{3}$	126	" "	2
Φ	$\frac{1}{8}\ \frac{1}{4}$	128	" "	2
W	$3\frac{3}{2}$	632	" "	2
T	$\frac{2}{3}\ \frac{1}{3}$	213	" "	2
$\mathfrak{n}$	$\frac{2}{5}\ \frac{1}{5}$	215	" "	2
$\mathfrak{Z}$	$-\frac{3}{4}\ \frac{1}{2}$	$\bar{3}24$	" "	2
ι	$-\frac{1}{4}\ \frac{1}{2}$	$\bar{1}24$	" "	2
J	$-\frac{3}{5}\ \frac{1}{15}$	$\bar{6}.1.15$	" "	2
K	-63	$\bar{6}31$	" "	2
μ	$-3\frac{3}{2}$	$\bar{6}32$	" "	2
$\mathfrak{m}$	$-\frac{6}{5}\ \frac{3}{5}$	$\bar{6}35$	" "	2
ξ	$-\frac{2}{3}\ \frac{1}{3}$	$\bar{2}13$	" "	2

t	$-\frac{2}{5}\ \frac{1}{5}$	$\bar{2}15$	Terlingua, Texas	2
𝔘	$-\frac{1}{3}\ \frac{1}{6}$	$\bar{2}16$	" "	2
A	$-\frac{2}{7}\ \frac{1}{7}$	$\bar{2}17$	" "	2
C	$-\frac{4}{3}\ \frac{1}{3}$	$\bar{4}13$	" "	2
𝔇	$-\frac{4}{5}\ \frac{1}{5}$	$\bar{4}15$	" "	2
𝔘	$-\frac{4}{11}\ \frac{1}{11}$	$\bar{4}.1.11$	" "	2
𝔊	$-\frac{4}{5}\ \frac{3}{5}$	$\bar{4}35$	" "	2
E	$-\frac{5}{3}\ \frac{1}{3}$	$\bar{5}13$	" "	2
𝔘	$-\frac{5}{9}\ \frac{1}{9}$	$\bar{5}19$	" "	2
𝔔	$-\frac{5}{4}\ \frac{1}{2}$	$\bar{5}24$	" "	2
𝔉	$-2\frac{1}{4}$	$\bar{8}14$	" "	2

1.—A. J. Moses, 1903, Amer. Journ. Sci., XVI, p. 225.

2.—W. F. Hillebrand and W. T. Schaller, 1909, U. S. Geol. Surv., Bull, CDV, p. 83.

Tetrahedrite

5∞	510	Servoz, Haute Savoie, France	9
4∞	410	Val de Ville, Alsace, France	6
$\frac{5}{3}\infty$	530	" " "	6
76.1	76.1.1	Imfeld, Binnenthal, Switzerland	2
34.1	34.1.1	Binnenthal, Switzerland	2
30.1	30.1.1	" "	3
28.1	28.1.1	Imfeld, Binnenthal, Switzerlan d	2
−28.1	28.$\bar{1}$.1	" " "	2
24.1	24.1.1	Binnenthal, Switzerland	3
18.1	18.1.1	" "	3
16.1	16.1.1	Imfeld, Binnenthal, Switzerland	2
12.1	12.1.1	" " "	2
10.1	10.1.1	" " "	2
−10.1	10.$\bar{1}$.1	Servoz, Haute-Savoie, France	9
91	911	Imfeld, Binnenthal, Switzerland	2
81	811	" " "	2
$\frac{3}{5}\frac{7}{5}1$	37.5.5	" " "	2
71	711	" " "	2
$1\frac{3}{2}1$	13.2.2	" " "	2
$\frac{3}{5}\frac{1}{5}1$	31.5.5	Val de Ville, Alsace, France	6
$\frac{2}{5}\frac{9}{5}1$	29.5.5	" " "	6
$\frac{1}{3}\frac{7}{3}1$	17.3.3?	" " "	6
$\frac{1}{2}\frac{1}{2}1$	11.2.2	Imfeld, Binnenthal, Switzerland	2
51	511	" " "	2
$\frac{4}{10}\frac{7}{10}1$	47.10.10	" " "	2

$\frac{2}{5}\frac{3}{}1$	23.5.5	Val de Ville, Alsace, France	6
$\frac{9}{2}1$	922	Imfeld, Binnenthal, Switzerland	2
$\frac{2}{5}\frac{2}{}1$	22.5.5	Val de Ville, Alsace, France	6
$\frac{2}{5}\frac{1}{}1$	21.5.5	" " "	6
$\frac{1}{5}\frac{9}{}1$	19.5.5	Imfeld, Binnenthal, Switzerland	2
$\frac{1}{5}\frac{8}{}1$	18.5.5	Val de Ville, Alsace, France	6
$\frac{7}{2}1$	722	Imfeld, Binnenthal, Switzerland	2
$\frac{1}{5}\frac{7}{}1$	17.5.5	Val de Ville, Alsace, France	6
$\frac{1}{5}\frac{6}{}1$	16.5.5	Imfeld, Binnenthal, Switzerland	2
$\frac{1}{6}\frac{9}{}1$	19.6.6	Binnenthal, Switzerland	3
$\frac{2}{1}\frac{9}{0}1$	29.10.10	" "	10
$\frac{1}{6}\frac{7}{}1$	17.6.6	" "	10
$\frac{1}{5}\frac{4}{}1$	14.5.5	Imfeld, Binnenthal, Switzerland	2
$\frac{2}{1}\frac{7}{0}1$	27.10.10	" " "	2
$\frac{8}{3}1$	833	Binnenthal, Switzerland	10
$\frac{1}{5}\frac{3}{}1$	13.5.5	Imfeld, Binnenthal, Switzerland	2
$\frac{5}{2}1$	522	" " "	2
$\frac{9}{4}1$	944	Val de Ville, Alsace, France	6
$\frac{1}{5}\frac{2}{}1$	12.5.5	Imfeld, Binnenthal, Switzerland	2
$\frac{1}{5}\frac{1}{}1$	11.5.5	Val de Ville, Alsace, France	6
$\frac{2}{1}\frac{1}{0}1$	21.10.10	Imfeld, Binnenthal, Switzerland	2
$\frac{1}{1}\frac{9}{0}$	19.10.10	Binnenthal, Switzerland	2
$\frac{1}{8}\frac{5}{}1$	15.8.8	Val de Ville, Alsace, France	6
$\frac{9}{5}1$	955	Imfeld, Binnenthal, Switzerland	2
$\frac{1}{7}\frac{3}{}1$	13.7.7	Val de Ville, Alsace, France	6
$\frac{7}{4}1$	744	" " "	6
$\frac{1}{1}\frac{7}{0}1$	17.10.10	Imfeld, Binnenthal, Switzerland	2
$\frac{1}{9}\frac{7}{}1$	17.9.9	Brixlegg, Tyrol	1
$\frac{5}{3}1$	533	Val de Ville, Alsace, France	6
$\frac{8}{5}1$	855	Imfeld, Binnenthal, Switzerland	2
$\frac{7}{5}1$	755	Binnenthal, Switzerland	2
$\frac{1}{1}\frac{3}{0}1$	13.10.10	Val de Ville, Alsace, France	6
π $\frac{6}{5}1$	655	Botes, Berge, Hungary	5
$\frac{7}{6}1$	766	Val de Ville, Alsace, France	6
$\frac{9}{8}1$	988	" " "	6
$\frac{2}{2}\frac{1}{0}1$	21.20.20	Framont, " "	4
62	62.62.1?	Val de Ville, " "	6
35	35.35.1	" " "	6
30	30.30.1	Imfeld, Binnenthal, Switzerland	2
14	14.14.1?	Val de Ville, Alsace, France	6

	12	12.12.1	Imfeld, Binnenthal, Switzerlamd	2
	9	991	Val de Ville, Alsace, France	6
	8	{881}	" " "	6
	—8	{88$\bar{1}$}	" " "	6
	$\frac{5}{2}$	552	Imfeld, Binnenthal, Switzerland	2
	$\frac{7}{3}$	773	Val de Ville, Alsace, France	6
	$\frac{9}{4}$	994	Imfeld, Binnenthal, Switzerland	2
	$\frac{11}{5}$	11.11.5	Binnenthal, Switzerland	2
	$\frac{9}{5}$	995	Val de Ville, Alsace, France	6
	$\frac{8}{5}$	{885}	Imfeld, Binnenthal, Switzerland	2
	—$\frac{8}{5}$	{88$\bar{5}$}	Binnenthal, Switzerland	2
	$\frac{7}{5}$	775	Val de Ville, Alsace, France	6
	$\frac{13}{10}$	13.13.10	" " "	6
	$\frac{4}{3}$	443	" " "	6
	$\frac{7}{6}$	776	Urbeis, Alsace, France	7
	$\frac{18}{17}$	18.17.17	Val de Ville, Alsace, France	6
	—7	7$\bar{7}$1	Framont, Alsace, France	4
	—$\frac{13}{2}$	13.$\bar{1}\bar{3}$.2	Imfeld, Binnenthal, Switzerland	2
	—$\frac{11}{2}$	11.$\bar{1}\bar{1}$.2	Framont, Alsace, France	4
	—4	4$\bar{4}$1	Imfeld, Binnenthal, Switzerland	2
	—3	3$\bar{3}$1	Binnenthal, Switzerland	2
	—$\frac{5}{2}$	5$\bar{5}$2	" "	2
	—$\frac{6}{5}$	6$\bar{6}$5	Val de Ville, Alsace, France	6
	—$\frac{29}{25}$	29.$\bar{2}\bar{9}$.25	" " "	6
	—$\frac{26}{25}$	26.$\bar{2}\bar{6}$.25	" " "	6
ν	52	{521}	Servoz, Haute-Savoie, France	9
	—52	{52$\bar{1}$}	Urbeis, Alsace, France	8
	$\frac{23}{11}\ \frac{12}{11}$	23.12.11	Imfeld, Binnenthal, Switzerland	2
λ	$\frac{9}{2}\ \frac{5}{2}$	952	Servoz, Haute-Savoie, France	9
	$\frac{5}{2}\ \frac{3}{2}$	{532}	Urbeis, Alsace, France	7
	—$\frac{5}{2}\ \frac{3}{2}$	{53$\bar{2}$}	Val de Ville, Alsace, France	6
	$2\frac{4}{3}$	643?	Urbeis, Alsace, France	7
	$\frac{5}{4}\ \frac{9}{8}$	10.9.8	" " "	7
	$\frac{6}{5}\ \frac{17}{15}$	18.17.15	" " "	7

1.—A. Cathrein, 1888, Min. u. petro. Mitth., X, p. 524.
2.—C. O. Trechmann, 1893, Min. Mag., X, p. 220.
3.—H. Baumhauer, 1893, Zeitschr. f. Kryst., XXI, p. 202.
4.—A. Brunlechner, 1895, Zeitschr. f. Kryst., XXIV, p. 628.
5.—K. Zimányi, 1901, Zeitschr. f. Kryst., XXXIV, p. 78.
6.—H. Ungemach, 1906, Bull. Soc. fr. Min., XXIX, p. 194.
7.—H. Ungemach, 1909, Bull. Soc. fr. Min., XXXII, p. 368.

8.—V. Dürfeld, 1909, Geol. Surv. Els.-Lothr., VII, p. 115.
9.—H. Ungemach, 1912, Bull. Soc. fr. Min., XXXV, p. 526.
10.—H. Baumhauer, 1913, Zeitschr. f. Kryst., LII, p. 580.

Thalénite

$a:b:c = 1.154:1:0.602 \quad \vartheta = 80° 12'$

c	0	001	Österby, Dalecalia, Sweden			1
a	$\infty 0$	100	"	"	"	1
b	0∞	010	"	"	"	1
m	∞	110	"	"	"	1
f	02	021	"	"	"	1
e	1	111	"	"	"	1
d	—1	$1\bar{1}1$	"	"	"	1
h	31	311	"	"	"	1

1.—C. Benedicks, 1898, Geol. Fören. Förh., XX, p. 308.

Thaumasite

Hexagonal $a:c = 1:0.931 \pm .003$

c	0	0001	West Paterson, N. J.			1
m	$\infty 0$	$10\bar{1}0$	"	"	"	1
a	∞	$11\bar{2}0$	"	"	"	2
e	$\frac{1}{2}0$	$10\bar{1}2$	"	"	"	2
f	$\frac{2}{3}0$	$20\bar{2}3$	"	"	"	2
p	10	$10\bar{1}1$	"	"	"	1
q	$\frac{3}{2}0$	$30\bar{3}2$	"	"	"	2

1.—W. T. Schaller, 1916, U. S. Geol. Surv., Bull. DCX, p. 131.
2.—E. T. Wherry, 1918, Proc. U. S. Nat. Mus., LIV, p. 373.

Thenardite

$a:b:c = 0.570:1:1.2541$

u	$\infty 3$	130	Aussee, Steiermark, Germany			1
v	$\frac{1}{3}$	113	"	"	"	1

1.—A. Pelikan, 1891, Min. u. petro. Mitth., XII, p. 476.

Thomsonite

$\infty \frac{1}{9}0$	9.10.0	Mte. Somma, Vesuvius, Italy		2
60	601	East Greenland		1

1.—O. B. Böggild, 1905, Medd. om Grönland, XXVIII, p. 109.
2.—G. Cesàro—1907, Bull. Ac. Belg., p. 334.

Thorianite

Isometric

	$\infty 0$	100	Balangoda, Ceylon	1

1.—W. R. Dunstan and G. S. Blake, 1905, Proc. Roy. Soc., A, p. 74.

Thortveitite

$a:b:c = 0.7456:1:1.4912$

m	∞	110	Iveland, Sätersdalen, Norway	1
s	2	221	" " "	1
o	1	111	" " "	1
u	$\frac{1}{2}$	112?	" " "	1

1.—J. Schetelig, 1911, Centralbl. Min., p. 721; 1912, idem, p. 64.

Tilasite

Monoclinic Clinohedral? $a:b:c = 0.7503:1:0.08391$ $\beta = 59° 30'$

a	$-\infty 0$	$\bar{1}00$	Kajlidongri, Jhabua, India	1
b	0∞	010	" " "	1
m	∞	110	" " "	1
m_1	$-\infty$	$\bar{1}10$	" " "	1
g	02	021	" " "	1
e	-10	$\bar{1}01$	" " "	1
p	1	111	" " "	1
p_1	$\bar{1}1$	$\bar{1}1\bar{1}$	" " "	1
x	$\bar{1}\bar{1}$	$11\bar{1}$	" " "	1
r_1	33	331	" " "	1
r	$\bar{3}3$	$\bar{3}3\bar{1}$	" " "	1
y	$\frac{1}{2}\,\frac{1}{2}$	$11\bar{2}$	" " "	1
o	$\bar{1}3$	$\bar{1}31$	" " "	1
z	$\frac{1}{2}\,\frac{5}{2}$	152	" " "	1
δ	$\frac{1}{3}\,\frac{6}{5}$	$1\bar{6}5$	" " "	1

1.—G. F. Herbert-Smith and G. T. Prior, 1911, Min. Mag., XVI, p. 84.

Titanite

$a:b:c = 0.4271:1:0.5676$ $\beta = 85° 27'$

o_1	6∞	610	Čáslav, Bohemia	10
	$\infty\frac{6}{5}$	560	Greenland	1
g	$0\frac{1}{3}$	013	Nordmark, Sweden	9
	$-\frac{1}{4}0$	$\bar{1}04$	Greenland	1
	$-\frac{3}{2}0$	$\bar{3}02$	"	1
	-20	$\bar{2}01$	Pian Real Mt., Piedmont, Italy	4

	$-\frac{1}{1\,1}$	$\bar{1}.1.11$	Valley of Gava, Voltri, Italy	11
	$-\frac{3}{2\,0}$	$\bar{3}.3.20$	Lauvital, Isère, France	2
R	$-\frac{1}{3}$	$\bar{1}13$	Skaatö, Kragerö, Norway	6
	$\frac{8}{3}$	883	Lauvital, Isère, France	2
h	—13	$\bar{1}31$	Nordmark, Sweden	9
	14	141	Watitz, Bohemia	3
	—21	$\bar{2}11$	Rauris, Tyrol	7
g	$-\frac{1}{2}12$	$\bar{1}.24.2$	Watitz, Bohemia	3
	$\frac{1}{3}\,\frac{8}{3}$	183	Rauris, Tyrol	7
e	$\frac{4}{3}5$	4.15.3	Watitz, Bohemia	3
	$-\frac{2}{5}\,\frac{7}{5}$	$\bar{2}75$	Rauris, Tyrol	7
	$-\frac{1}{9}\,\frac{1}{3}$	$\bar{1}39$	Greenland	1
	$-\frac{5}{1\,1}\,\frac{6}{1\,1}$	$\bar{5}.6.11$	Rauris, Tyrol	7
g	$\frac{1}{5}\,\frac{1}{7}$	7.5.35	Switzerland	5
	—43	$\bar{4}31$	Greenland	1
u_1	$-\frac{1}{3}\,\frac{2}{9}$	$\bar{3}29$	Switzerland	5
u_2	$-\frac{1}{3}\,\frac{1}{6}$	$\bar{2}16$	"	5
c'	$\frac{3}{5\,0}\,\frac{1}{5\,0}$	3.1.50	Val Giuf, Isivizzera, Italy	8
Λ	$\frac{3}{7}\,\frac{1}{7}$	317	" " "	8
u_3	$-\frac{1}{3}\,\frac{1}{9}$	$\bar{3}19$	Switzerland	5
	$-\frac{3}{4}\,\frac{1}{4}$	$\bar{3}14$	Rauris, Tyrol	7
N	$-\frac{1}{3}\,\frac{1}{2}\frac{3}{0}$	$\bar{2}0.39.60$	Watitz, Bohemia	3

1.—G. Flink, 1893, Geol. Fören. Förh., XV, p. 467.
2.—P. Ternier, 1896, Bull. Soc. fr. Min., XIX, p. 81.
3.—A. Krejci, 1898, Ber. böhm. Ges. Wiss., IX.
4.—B. Boeris, 1902, Att. Soc. Milano, XLI, p. 357.
5.—O. Hugo, 1904, Centralbl. f. Min., p. 464.
6.—F. Slavik, 1904, Zeitschr. f. Kryst., XXXIX, p. 301.
7.—H. Scisser, 1910, Zeitschr. f. Kryst., XLVII, p. 321.
8.—F. Ranfaldi, 1913, Mem. Accad. Linc., (5) IX, p. 23.
9.—A. Hadding, 1914, Geol. Fören. Förh., XXXVI, p. 319.
10.—B. Jezik, 1914, Zeitschr. d. böhm. Mus., Sept.-Abdr., p. 6.
11.—E. Repossi, 1918, Att. Soc. Ital. Sci. Nat., LVII, p. 131.

Topaz

a: b: c = 0.52854:1:0.95338

h^6	$\frac{7}{5}\infty$	750	Zacatecas, Mexico	11
	$\frac{9}{7}\infty$	970	Minas Geraes, Brazil	14
	$\infty\frac{1}{1}\frac{8}{7}$	17.18.0	" " "	14
	$\infty\frac{1}{1}\frac{6}{5}$	15.16.0	" " "	14
	$\infty\frac{1}{1}\frac{5}{4}$	14.15.0?	Ilmen Mts., Russia	2

	$\infty\frac{14}{13}$	13.14.0	Bahia, Brazil	15
	$\infty\frac{11}{10}$	10.11.0	Minas Geraes, Brazil	14
	$\infty\frac{15}{13}$	13.15.0?	Bahia, Brazil	15
	$\infty\frac{7}{6}$	670	Minas Geraes, Brazil	14
	$\infty\frac{9}{7}$	790	" " "	14
	$\infty\frac{17}{13}$	13.17.0	" " "	14
	$\infty\frac{18}{13}$	13.18.0	Bahia, Brazil	15
	$\infty\frac{7}{5}$	570?	" "	15
	$\infty\frac{8}{5}$	580	Ilmen Mts., Russia	2
	$\infty\frac{13}{8}$	8.13.0	Minas Geraes, Brazil	14
	$\infty\frac{5}{3}$	350	" " "	14
	$\infty\frac{11}{6}$	6.11.0	" " "	14
	$\infty\frac{15}{7}$	7.15.0	" " "	14
	$\infty\frac{13}{6}$	6.13.0	" " "	14
	$\infty\frac{9}{4}$	490	" " "	14
	$\infty\frac{7}{3}$	370	" " "	14
	$\infty\frac{12}{5}$	5.12.0	" " "	14
	$\infty\frac{13}{5}$	5.13.0	" " "	14
	$\infty\frac{17}{6}$	6.17.0	" " "	14
	$\infty\frac{11}{4}$	4.11.0	Japan	3
	$\infty\frac{11}{3}$	3.11.0	Minas Geraes, Brazil	14
	$\infty\frac{9}{2}$	290	Ilmen Mts., Russia	2
	$\infty 16$	1.16.0?	" "	2
	$0\frac{9}{8}$	098	Minas Geraes, Brazil	14
	$0\frac{5}{4}$	054	" " "	14
	$0\frac{11}{9}$	0.11.9	" " "	14
	$0\frac{16}{13}$	0.16.13	Bahia "	15
W	$0\frac{4}{3}$	043	Minas Geraes, "	8
	$0\frac{8}{5}$	085	Bahia "	15
Γ	$0\frac{8}{3}$	083	Minas Geraes, "	8
ω:	06	061	" " "	13
	0.18	0.18.1	" " "	14
	$\frac{1}{7}0$	107		6
j	50	501	Parkenham, Victoria, Australia	7
	$\frac{1}{6}$	116?	Ilmen Mts., Russia	2
	$\frac{2}{9}$	229	Bahia, Brazil	15
	$\frac{3}{8}$	338	Ilmen Mts., Russia	4
	$\frac{7}{17}$	7.7.17	Bahia, Brazil	15
	$\frac{7}{16}$	7.7.16		1
	$\frac{4}{9}$	449	Bahia, Brazil	15

	$\frac{9}{2}\frac{}{0}$	9.9.20	Fichtelgebirge, Saxony, Germany	5
	$\frac{7}{1}\frac{}{3}$	7.7.13	Minas Geraes, Brazil	14
	$\frac{4}{7}$	447	" " "	14
a:	$\frac{2}{3}$	223	" " "	10
o:	$\frac{4}{5}$	445	" " "	13
e	4	441	Japan	11
	$\frac{1}{3}\frac{}{2}$ 1	1.32.32?	Ilmen Mts., Russia	2
	$\frac{1}{1}\frac{}{4}$ $\frac{1}{1}\frac{3}{4}$	1.13.14	Minas Geraes, Brazil	14
	$\frac{1}{4}\frac{0}{1}$ $\frac{3}{4}\frac{1}{1}$	10.31.14?	Ilmen Mts., Russia	2
b:	$\frac{2}{5}\frac{}{5}$	235	Minas Geraes, Brazil	9
	$\frac{4}{9}\frac{0}{7}$ $\frac{5}{9}\frac{7}{7}$	40.57.97?	Ilmen Mts., Russia	2
	$\frac{2}{4}\frac{0}{7}$ $\frac{2}{4}\frac{7}{7}$	20.27.47?	" "	2
	$\frac{1}{2}\frac{0}{3}$ $\frac{1}{2}\frac{3}{3}$	10.13.23?	" "	2
	$\frac{4}{9}\frac{}{}$ $\frac{5}{9}$	459?	" "	2
	$\frac{8}{1}\frac{}{5}$ $\frac{7}{1}\frac{}{5}$	8.7.15	" "	2
	$\frac{2}{3}\frac{0}{}$ $\frac{1}{3}\frac{7}{}$	20.17.3?	" "	2
	$\frac{4}{7}\frac{}{}$ $\frac{3}{7}$	437?	" "	2
	$\frac{1}{1}\frac{1}{0}$ $\frac{8}{1}\frac{}{0}$	11.8.10	Elba, Italy	12
i:	$\frac{1}{3}\frac{}{}$ $\frac{1}{9}$	319	Japan	10
	$\frac{5}{7}\frac{}{}$ $\frac{8}{3}\frac{}{5}$	25.8.35?	Ilmen Mts., Russia	2
	$\frac{1}{1}\frac{0}{3}$ $\frac{3}{1}\frac{}{3}$	10.3.13	" "	2
	$\frac{4}{5}\frac{}{}$ $\frac{1}{5}$	415	" "	2
	$\frac{1}{1}\frac{1}{3}$ $\frac{2}{1}\frac{}{3}$	11.2.13?	" "	2

1.—G. Cesàro, 1889, Bull. Soc. fr. Min., XII, p. 419.
2.—L. Sonheur, 1892, Zeitschr. f. Kryst., XX, p. 231.
3.—W. D. Matthew, 1892, School of Mines Quar., XIV, p. 53.
4.—P. Jeremejew, 1893, Zeitschr. f. Kryst., XXII, p. 74.
5.—H. Bucking, 1896, Ber. Senckenberg Ges., p. 147.
6.—F. Slavic, 1902, Bull. Acad. Sci. Böhm.
7.—C. Anderson, 1908, Rec. Austr. Mus., VII, p. 61.
8.—V. Goldschmidt and F. Sauer, 1910, Zeitschr. f. Kryst., XLVII, p. 644.
9.—V. Goldschmidt, 1910, Zeitschr. f. Kryst., XLVII, p. 639.
10.—V. Rosicky, 1910, Abh. d. böhm. Acad.
11.—H. Ungemach, 1910, Bull. Soc. fr. Min., XXXIII, p. 28.
12.—V. Panichi, 1911, Rend. Accad. Linc., (2) XX, p. 279.
13.—V. Goldschmidt and V. Rosicky, 1913, Verh. Nat.-Med. Ver. Heidel, XII, p. 249.
14.—D. Fenner, 1913, Neues Jahrb. f. Min., Beil.-B., XXXVI, p. 204.
15.—P. Siedel, 1915, Neues Jahrb. f. Min., Beil.-B., XXXVIII, p. 775.

Tourmaline

25∞	$25.1.\overline{26}.0$	Brazil	4
15∞	$15.1.\overline{16}.0$	"	4

	$\frac{4}{3}\frac{0}{\infty}$	40.3.$\bar{4}\bar{3}$.0	Brazil	4
	10∞	10.1.$\bar{1}\bar{1}$.0	Ceylon	5
	8∞	8$\bar{1}$90	"	5
	$\frac{1}{2}\frac{3}{\infty}$	13.2.$\bar{1}\bar{5}$.0	Bahia, Brazil	7
	6∞	6$\bar{1}$70	Brazil	4
	$\frac{1}{2}\frac{1}{\infty}$	11.2.$\bar{1}\bar{3}$.0	"	4
	$\frac{1}{3}\frac{1}{\infty}$	11.3.$\bar{1}\bar{4}$.0	"	4
	$\frac{7}{2}\infty$	72$\bar{9}$0	"	4
	$\frac{1}{3}\frac{0}{\infty}$	10.3.$\bar{1}\bar{3}$.0	"	4
	$\frac{7}{3}\infty$	7.3.$\bar{1}\bar{0}$.0	"	4
	$\frac{2}{9}\frac{0}{\infty}$	20.9.$\bar{2}\bar{9}$.0	Bahia, Brazil	7
	$\frac{1}{8}\frac{7}{\infty}$	17.8.$\bar{2}\bar{5}$.0	Minas Geraes, Brazil	3
	$\frac{1}{7}\frac{1}{\infty}$	11.7.$\bar{1}\bar{8}$.0	Bahia, Brazil	7
	$\frac{1}{9}\frac{0}{\infty}$	10.9.$\bar{1}\bar{9}$.0	Brazil	4
	$\frac{2}{2}\frac{5}{3}\infty$	25.23.$\bar{4}\bar{8}$.0	Bahia, Brazil	7
	$-\frac{1}{8}\frac{1}{\infty}$	$\bar{1}\bar{1}$.$\bar{8}$.$\bar{1}\bar{9}$.0	Ceylon	2
	$-\frac{1}{7}\frac{0}{\infty}$	$\bar{1}\bar{0}$.$\bar{7}$.$\bar{1}\bar{7}$.0	"	2
	$-\frac{5}{4}\infty$	$\bar{4}$5$\bar{9}$0	"	2
	$-\frac{6}{5}\infty$	$\bar{6}$.$\bar{5}$.$\bar{1}\bar{1}$.0	"	2

Antilogous Pole

	$\frac{1}{9}$	11$\bar{2}$9	Ceylon	2
	$\frac{2}{1\,1}$	2.2.$\bar{4}$.11	"	2
	$\frac{5}{1\,4}$	5.5.$\bar{1}\bar{0}$.14	"	2
	$\frac{5}{1\,2}$	5.5.$\bar{1}\bar{0}$.12	"	2
τ	$\frac{2}{3}$	22$\bar{4}$3	"	2
	2	22$\bar{4}$1	"	2
	$\frac{2}{1\,1}0$	2.0.$\bar{2}$.11	"	2
η	$\frac{2}{5}0$	20$\bar{2}$5	"	2
	$\frac{4}{7}0$	40$\bar{4}$7	"	2
	$\frac{2}{3}0$	20$\bar{2}$3	"	2
	$\frac{5}{4}0$	50$\bar{5}$4	"	2
	$\frac{1}{7}\frac{0}{}0$	10.0.$\bar{1}\bar{0}$.7	"	2
l	$\frac{9}{5}0$	90$\bar{9}$5	"	5
i	20	20$\bar{2}$1	"	2
	$\frac{1}{5}\frac{4}{}0$	14.0.$\bar{1}\bar{4}$.5	"	2
F	30	30$\bar{3}$1	"	2
m	$\frac{1}{4}\frac{3}{}0$	13.0.$\bar{1}\bar{3}$.4	"	2
	$\frac{9}{2}0$	90$\bar{9}$2	"	2
	$\frac{1}{2}\frac{1}{}0$	11.0.$\bar{1}\bar{1}$.2	"	2

P	70	$70\bar{7}1$	Ceylon	2
	130	$13.0.\bar{13}.1$	"	2
	$-\frac{1}{5}0$	$01\bar{1}5$	"	2
	$-\frac{1}{4}0$	$01\bar{1}4$	"	2
	$-\frac{1}{3}0$	$01\bar{1}3$	"	2
	$-\frac{4}{9}0$	$04\bar{4}9$	"	2
	$-\frac{5}{8}0$	$05\bar{5}8$	"	2
	$-\frac{5}{7}0$	$05\bar{5}7$	"	2
ϵ	$-\frac{4}{5}0$	$04\bar{4}5$	"	2
	$-\frac{13}{14}0$	$0.13.\bar{13}.14$	"	2
	$-\frac{8}{7}0$	$08\bar{8}7$	"	2
Δ	$-\frac{3}{2}0$	$03\bar{3}2$	"	2
ψ	-30	$03\bar{3}1$	"	2
$\mathfrak{r}$	$-\frac{17}{3}0$	$0.17.\bar{17}.3$	"	5
$\mathfrak{k}$	$-\frac{20}{3}0$	$0.20.\bar{20}.3$	"	5
$\mathfrak{H}$	-80	$08\bar{8}1$	"	2
$\mathfrak{n}$	$-\frac{17}{2}0$	$0.17.\bar{17}.2$	"	5
$\mathfrak{o}$	-10.0	$0.10.\bar{10}.1$	"	5
$\mathfrak{p}$	-17.0	$0.17.\bar{17}.1$	"	5
		Analogous Pole		
	$-\frac{11}{10}0$	$0.\bar{11}.11.\bar{10}$	Ceylon	2
N'	$-\frac{5}{2}0$	$05\bar{5}2$	"	2
	$-\frac{11}{4}0$	$0.\bar{11}.11.\bar{4}$	"	2
π'	-70	$07\bar{7}1$	"	2
	$-\frac{19}{2}0$	$0.9\bar{1}.19.\bar{2}$	"	2
		Antilogous Pole		
	51	$51\bar{6}1$	Elba, Italy	2
β	$\frac{11}{8}\ \frac{3}{8}$	$11.3.\bar{14}.8$	Ceylon	2
	$\frac{14}{9}\ \frac{5}{9}$	$14.5.\bar{19}.9$	"	2
	$\frac{17}{10}\ \frac{7}{10}$	$17.7.\bar{24}.10$	"	2
	$\frac{13}{6}\ \frac{7}{6}$	$13.7.\bar{20}.6$	"	2
	$\frac{7}{3}\ \frac{4}{3}$	$7.4.\bar{11}.3$	"	2
h	$\frac{5}{2}\ \frac{3}{2}$	$53\bar{8}2$	"	2
y	$\frac{7}{2}\ \frac{5}{2}$	$7.5.\bar{12}.2$	"	2
	$\frac{15}{4}\ \frac{11}{4}$	$15.11.\bar{26}.4$	"	2
	$\frac{9}{2}\ \frac{7}{2}$	$9.7.\bar{16}.2$	"	2
	54	$54\bar{9}1$	"	2
	$\frac{15}{2}\ \frac{13}{2}$	$15.13.\bar{28}.2$	"	2
Σ	13.12	$13.12.\bar{25}.1$	"	2

ȸ	20.19	20.19.$\bar{3}\bar{9}$.1	Ceylon	2
ℜ	$\frac{1}{4}$ $\frac{3}{8}$	23$\bar{5}$8	"	2
Q	$\frac{1}{5}$ $\frac{2}{5}$	12$\bar{3}$5	"	2
ℚ	$\frac{1}{6}$ $\frac{5}{12}$	2.5.$\bar{7}$.12	"	2

Analogous Pole

	$\frac{16}{15}$ $\frac{1}{15}$	$\bar{1}\bar{6}$.$\bar{1}$.17.$\bar{1}\bar{5}$	Ceylon	2
	$\frac{12}{11}$ $\frac{1}{11}$	$\bar{1}\bar{2}$.$\bar{1}$.13.$\bar{1}\bar{1}$	"	2
$\mathfrak{M}'$	$\frac{10}{9}$ $\frac{1}{9}$	$\bar{1}\bar{0}$.$\bar{1}$.11.$\bar{9}$	"	2
ρ'	$\frac{6}{5}$ $\frac{1}{5}$	$\bar{6}\bar{1}\bar{7}\bar{5}$	"	2
f'	$\frac{4}{3}$ $\frac{1}{3}$	$\bar{4}\bar{1}\bar{5}\bar{3}$	"	2
β	$\frac{11}{8}$ $\frac{3}{8}$	$\bar{1}\bar{1}$.$\bar{3}$.14.$\bar{8}$	"	2
$\mathfrak{c}'$	$\frac{10}{7}$ $\frac{3}{7}$	$\bar{1}\bar{0}$.$\bar{3}$.13.$\bar{7}$	"	2
	$\frac{17}{10}$ $\frac{7}{10}$	$\bar{1}\bar{7}$.$\bar{7}$.24.$\bar{1}\bar{0}$	"	2
	$\frac{11}{6}$ $\frac{5}{6}$	$\bar{1}\bar{1}$.$\bar{5}$.16.$\bar{6}$	"	2
	$\frac{9}{4}$ $\frac{5}{4}$	$\bar{9}$.$\bar{5}$.14.$\bar{4}$	"	2
	$\frac{7}{3}$ $\frac{4}{3}$	$\bar{7}$.$\bar{4}$.11.$\bar{3}$	"	2
y'	$\frac{7}{2}$ $\frac{5}{2}$	$\bar{7}$.$\bar{5}$.12.2	"	2
H'	43	$\bar{4}\bar{3}\bar{7}\bar{1}$	"	2
J'	54	$\bar{5}\bar{4}\bar{9}\bar{1}$	"	2
	76	$\bar{7}$.$\bar{6}$.13.$\bar{1}$	"	2
L'	$\frac{15}{2}$ $\frac{13}{2}$	$\bar{1}\bar{5}$.$\bar{1}\bar{3}$.28.$\bar{2}$	"	2
Σ'	13.12	$\bar{1}\bar{3}$.$\bar{1}\bar{2}$.25.$\bar{1}$	"	2
T'	18.17	$\bar{1}\bar{8}$.$\bar{1}\bar{7}$.35.$\bar{1}$	"	2
	$-\frac{3}{8}$ $\frac{1}{4}$	$\bar{2}\bar{3}\bar{5}\bar{8}$	"	2

Antilogous Pole

	$\frac{11}{12}$ $\frac{1}{6}$	11.2.$\bar{1}\bar{3}$.12	Ceylon	2
	$\frac{9}{10}$ $\frac{1}{5}$	9.2.$\bar{1}\bar{1}$.10	"	2
	$\frac{7}{8}$ $\frac{1}{4}$	72$\bar{9}$8	"	2
	$\frac{9}{11}$ $\frac{4}{11}$	9.4.$\bar{1}\bar{3}$.11	"	2
	$\frac{4}{5}$ $\frac{2}{5}$	42$\bar{6}$5	"	2
w	$\frac{3}{4}$ $\frac{1}{2}$	32$\bar{5}$4	"	2
	$-\frac{8}{7}$ $\frac{3}{7}$	3.8.$\bar{1}\bar{1}$.7	"	2
	$-\frac{5}{4}$ $\frac{3}{8}$	3.10.$\bar{1}\bar{3}$.8	"	2
M	$-\frac{4}{3}$ $\frac{1}{3}$	14$\bar{5}$3	"	2
ɐ	$-\frac{7}{5}$ $\frac{3}{10}$	3.14.$\bar{1}\bar{7}$.10	"	2
	$-\frac{8}{5}$ $\frac{1}{5}$	18$\bar{9}$5	"	2
ɡ	$-\frac{5}{2}$ $\frac{1}{2}$	15$\bar{6}$2	"	2
ü	$-\frac{17}{4}$ $\frac{9}{4}$	9.17.$\bar{2}\bar{6}$.4	"	2
Z	-75	5.7.$\bar{1}\bar{2}$.1	"	2

D	—86	6.8.$\bar{14}$.1	Ceylon	2
$\mathfrak{D}$	$\frac{8}{3}\,\frac{2}{3}$	8.2.$\bar{10}$.3	"	2
X	$\frac{9}{2}\,\frac{1}{2}$	9.1.$\bar{10}$.2	"	2
E	51	51$\bar{6}$1	Elba, Italy	1
K	62	62$\bar{8}$1	Ceylon	2
	$-2\frac{3}{7}$	3.14.$\bar{17}$.7	"	2
$\mathfrak{P}$	$-2\frac{3}{5}$	3.10.$\bar{13}$.5	"	2
$\mathfrak{M}$	$-2\frac{2}{3}$	26$\bar{8}$3	"	2
B	—21	12$\bar{3}$1	"	2
T	$-2\frac{7}{2}$	34$\bar{7}$2	"	2
	52	52$\bar{7}$1	"	2
	$1\frac{5}{2}2$	15.4.$\bar{19}$.2	"	2
j	$-1\frac{1}{4}$	14$\bar{5}$4	"	2
	$-1\frac{1}{7}$	17$\bar{8}$7	"	2
	$-1\frac{1}{9}$	$\bar{2}$97$\bar{9}$	"	2
	$-1\frac{1}{4}\,\frac{3}{4}$	3.11.$\bar{14}$.4	Madagascar	6

Analogous Pole

	$\frac{5}{7}\,\frac{4}{7}$	$\bar{5}$49$\bar{7}$	Ceylon	2
x′	$-1\frac{1}{2}$	$\bar{1}$23$\bar{2}$	"	2
C′	$-1\frac{2}{7}^{0}$	$\bar{2}0.\bar{7}.27.\bar{7}$	"	2

1.—G. d'Archiardi, 1894, Att. Soc. Tosc. Mem. Pisa, XII, p. 229.
*2.—V. vonWorobieff, 1900, Zeitschr. f. Kryst., XXXIII, p. 263.
3.—A. H. Westergård, 1906, Zeitschr. f. Kryst., XLII, p. 276.
4.—G. Reimann, 1907, Neues Jahrb. f. Min. Beil.-B., XXIII, p. 91.
5.—A. Ondřef, 1909, Abh. d. böhm. Akad.
6.—H. Ungemach, 1912, Bull. Soc. fr. Min., XXXV.
7.—P. Siedel, 1915, Neues Jahrb. f. Min. Beil.-B., XXXVIII, p. 792.

Trechmannite

Hexagonal Trirhombohedral *a*: *c* = 1:0.6530

o	0	0001	Binnenthal, Switzerland[1]		1
b	$\infty 0$	10$\bar{1}$0	"	"	1
f	$\infty 7$	17$\bar{8}$0	"	"	1
F	$\infty 4$	14$\bar{5}$0	"	"	2
d	$\infty 3$	13$\bar{4}$0	"	"	1
a	∞	11$\bar{2}$0	"	"	1
r	10	10$\bar{1}$1	"	"	1
α	40	40$\bar{4}$1	"	"	2

[1]Lengenbach Quarry, Binnenthal, Switzerland.

H	$-\frac{1}{5}0$	$01\bar{1}5$	Binnenthal, Switzerland [1]		2
G	$-\frac{2}{7}0$	$02\bar{2}7$	"	"	2
e	$-\frac{1}{2}0$	$01\bar{1}2$	"	"	2
s	-20	$02\bar{2}1$	"	"	2
φ	-50	$05\bar{5}1$	"	"	2
p	$\frac{1}{3}$	$11\bar{2}3$	"	"	2
v	21	$21\bar{3}1$	"	"	2
χ	43	$43\bar{7}1$	"	"	2
V	62	$62\bar{8}1$	"	"	2
s	53	$53\bar{8}1$	"	"	2
β	$\frac{3}{4}\ \frac{1}{2}$	$32\bar{5}4$	"	"	2
n	$-\frac{4}{3}\ \frac{1}{3}$	$14\bar{5}3$	"	"	2
x	-31	$13\bar{4}1$	"	"	1
z	-42	$24\bar{6}1$	"	"	1
θ	$-\frac{2}{9}\ \frac{9}{9}\ \frac{2}{9}$	$2.29.\bar{3}1.9$	"	"	2
k	$-\frac{1}{8}\ \frac{1}{8}\ \frac{1}{8}$	$1.11.\bar{1}2.8$	"	"	2
λ	$-\frac{1}{5}\ \frac{1}{5}\ \frac{1}{5}$	$1.11.\bar{1}2.5$	"	"	2
σ	$-\frac{9}{4}1$	$4.9.\bar{1}3.4$	"	"	2
ϵ	$-\frac{1}{8}\ \frac{3}{8}\ \frac{3}{4}$	$6.13.\bar{1}9.4$	"	"	2
g	$-\frac{5}{4}\ \frac{3}{4}$	$35\bar{8}4$	"	"	2
γ	$-\frac{5}{2}2$	$45\bar{9}2$	"	"	2
η	$-\frac{3}{5}\ \frac{2}{5}$	$23\bar{5}5$	"	"	2

1.—R. H. Solly, 1905, Min. Mag., XIV, p. 75.
2.—G. F. Herbert-Smith and G. T. Prior, 1907, Min. Mag., XIV, p. 300.

Trögerite

Tetragonal? $a:c=1:2.16$

o	0	001	Schneeberg, Saxony, Germany			1
n	0∞	010	"	"	"	1
Σ	$\infty 2$	120	"	"	"	1
y	$0\frac{1}{2}$	012	"	"	"	1
P	01	011	"	"	"	1
h	$0\frac{3}{2}$	032	"	"	"	1
i	02	021	"	"	"	1
t	1	111	"	"	"	1
u	3	331	"	"	"	1

1.—V. Goldschmidt, 1899, Zeitschr. f. Kryst., XXXI, p. 468.

[1]Legenbach Quarry, Binnenthal, Switzerland.

Trona

t	$-\frac{1}{2}0$	$\bar{1}02$	Vesuvius, Italy	1

1.—F. Zambonini, 1908, Att. R. Acc. Sc. Napoli, XIII.

Tscheffkinite

a: b: c = 0.9238:1:0.4900

	0	001	Betroku, Madagascar	1
	0∞	010	" "	1
	$\frac{7}{2}\infty$	720	" "	1
	$\frac{5}{2}\infty$	520	" "	1
	∞	110	" "	1
	10	101	" "	1
	1	111	" "	1

1.—H. Ungemach, 1916, Bull. Soc. fr. Min., XXXIX.

Tsumebite

a: b: c = 0.977:1:0.879

c	0	001	Tsumeb, Otavi, S. W. Africa				1
d	10	101	"	"	"	"	1
e	20	201	"	"	"	"	1
p	1	111	"	"	"	"	1
n	12	121	"	"	"	"	1

1.—V. Rosicky, 1912, Zeitschr. f. Kryst., LI, p. 521.

Turquois

a: b: c = 0.7910:1:0.6051 $\alpha = 92° 50'$ $\beta = 93° 30'$ $\gamma = 107° 41'$

a	$\infty 0$	100	Lynch Station, Campbell Co., Va.				1
b	0∞	010	"	"	"	"	1
m	∞	110	"	"	"	"	1
M	$-\infty$	$1\bar{1}0$	"	"	"	"	1
k	-01	$0\bar{1}1$	"	"	"	"	1

1.—W. T. Schaller, 1912, Amer. Journ. Sci., XXXIII, p. 35.

Tychite

Isometric

o	1	111	Borax Lake, Calif.	1

1.—S. L. Penfield and G. S. Jamieson, 1905, Amer. Journ. Sci., XX, p. 217.

Uhligite

Isometric

	$\infty 0$	100	Magad Lake, East Africa	1
	1	101	" " " "	1

1.—O. Hauser, 1909, Zeitschr. Anorg. Chem., LXIII, p. 340.

Uranophane

$a:b:c = 0.6257:1:0.5943$ $\alpha = 87° 41'$ $\beta = 58° 18'$ $\gamma = 96° 31'$

C	0	001	Saxony and Bohemia[1]	1
A	$\infty 0$	100	" " "	1
B	0∞	010	" " "	1
r	-6∞	$6\bar{1}0$	" " "	1
l	2∞	210	" " "	1
u	$\infty 6$	160?	" " "	1
o	$\infty 7$	170?	" " "	1
t	$\infty 12$	1.12.0?	" " "	1
ω	$\infty 20$	1.20.0?	" " "	1
T	01	011?	" " "	1
D	10	101?	" " "	1
p	1	111?	" " "	1
s	$1\bar{1}$	$1\bar{1}1$?	" " "	1
π	$\frac{1}{3}1$	$\bar{1}33$?	" " "	1
Θ	$\frac{\bar{1}}{3}\bar{1}$	$\bar{1}\bar{3}3$?	" " "	1
Σ	$1\frac{2\,0}{1\,\bar{1}}$	$11.2\bar{0}.11$?	" " "	1
σ	$\frac{2\,0}{9}1$	$2\bar{0}.9.9$?	" " "	1
α	17.1	17.1.1?	" " "	1
μ	$\bar{1}\bar{1}.1$	$\bar{1}\bar{1}.1.1$?	" " "	1
β	$10.\bar{1}$	$10.\bar{1}.1$?	" " "	1
γ	$\bar{1}0.\bar{1}$	$\bar{1}0.\bar{1}.1$?	" " "	1
ϵ	$8\bar{1}$	$8\bar{1}1$?	" " "	1
σ	$7\bar{1}$	$7\bar{1}1$?	" " "	1

1.—P. Pjatnitzki, 1892, Zeitschr. f. Kryst., XXI, p. 74.

Valentinite

0.3936:1:0.4339 (Ungemach)

c	0	001	La Nurra, Sardinia	1
g^3	$\infty 2$	120	Sensa, "	3
g^2	$\infty 3$	130	" "	3

[1]Schneeberg Saxony and Joachimsthal, Bohemia.

e^2	$0\frac{1}{2}$	012	Sensa, Sardinia	3
b'	$\frac{1}{2}$	112	" "	3
	1	111	Tatasi, Bolivia	2
$b\frac{1}{8}$	4	441	Sensa, Sardinia	3
α	13	131	" "	3
t	$\frac{1}{3}1$	133[4.6.31]	La Nurra, Sardinia	1

1.—A. Pelloux, 1904, Rend. Accad. Linc., XIII, (2), p. 34.
2.—L. J. Spencer, 1907, Min. Mag., XIV, p. 328.
*3.—H. Ungemach, 1912, Bull. Soc. fr. Min., XXXV, p. 539.

Vanadinite

f	5∞	$51\bar{6}0$	Hillsboro, New Mex.	1
g	3∞	$31\bar{4}0$	" "	1
d	$\frac{5}{3}\infty$	$53\bar{8}0$	Yuma Co., Ariz.	2
k	$\frac{3}{4}0$	$30\bar{3}4$	" "	2
o	$\frac{7}{6}0$	$70\bar{7}6$	" "	2
δ	$\frac{5}{4}0$	$50\bar{5}4$	Hillsboro, New Mex.	1
γ	$\frac{4}{3}0$	$40\bar{4}3$	" "	1
u	$\frac{7}{5}0$	$70\bar{7}5$	Yuma Co., Ariz.	2
α	$\frac{3}{2}0$	$30\bar{3}2$	Hillsboro, New Mex.	1
B	$\frac{5}{3}0$	$50\bar{5}3$	" "	1
A	$\frac{7}{4}0$	$70\bar{7}4$	Yuma Co., Ariz.	2
H	$\frac{7}{2}0$	$70\bar{7}2$	" "	2
K	$\frac{11}{3}0$	$11.0.\bar{11}.3$	" "	2
π	40	$40\bar{4}1$	Hillsboro, New Mex.	1
η	$\frac{3}{2}$	$33\bar{6}2$	Cutter and Kelly, New Mex.	3
σ	2	$22\bar{4}1$	" " " "	3
ξ	$1\frac{1}{4}$	$41\bar{5}4$	Hillsboro, New Mex.	1
p	$2\frac{1}{2}$	$41\bar{5}2$?	" "	1
t	$\frac{5}{2}1$	$52\bar{7}2$	" "	1
i	$1\frac{1}{2}$	$21\bar{3}2$	" "	1
e	$1\frac{2}{3}$	$32\bar{5}3$	" "	1
l	$1\frac{3}{2}$	$32\bar{5}2$	" "	1

1.—V. Goldschmidt, 1900, Zeitschr. f. Kryst., XXXII, p. 561.
2.—W. T. Schaller, 1905, U. S. Geol. Surv., Bull. CCLXII, p. 135.
3.—F. P. Paul, 1912, Zeitschr. f. Kryst., L, p. 600.

Varisite

$a:b:c = 0.8944:1:1.0919$

c	0	001	Lucin, Utah	2
a	$\infty 0$	100	" "	1

b	0∞	010	Lucin, Utah	1
f	$\frac{5}{2}\infty$	520	" "	2
q	2∞	210	" "	2
m	∞	110	" "	1
h	$\infty\frac{4}{3}$	340	" "	2
d	$\infty 2$	120	" "	2
j	$\infty\frac{5}{2}$	250	" "	2
l	$\infty 3$	130	" "	2
e	$0\frac{1}{2}$	012	" "	1
g	$0\frac{3}{2}$	032	" "	2
t	$\frac{1}{2}0$	102	" "	2
p	1	111	" "	2

1.—W. T. Schaller, 1912, Proc. Nat. Mus., XLI, p. 413.
2.—W. T. Schaller, 1916, U. S. Geol. Surv., Bull. DCX, p. 69.

Vesuvianite

	3∞	310	Tennberg, Delecarlia, Sweden	2
	$\frac{9}{4}\infty$	940	Vesuvius	4
	$\frac{6}{5}\infty$	650	Tennberg, Delecarlia, Sweden	2
T	$\frac{1}{6}0$	106	Monte Somma, Italy	1
S	$\frac{2}{9}$	229	" " "	1
V	$\frac{5}{2}$	552	" " "	1
W	$\frac{1}{5}\frac{4}{}$	14.14.5	" " "	1
	$\frac{1}{4}\frac{3}{}$	13.13.4?	Zermatt, Switzerland	1
D	$\frac{1}{5}\frac{8}{}1$	18.5.5	Monte Somma, Italy	1
K	$\frac{7}{2}1$	722	" " "	1
n	$\frac{5}{4}\ \frac{1}{4}$	514	Crestmore, Riverside Co., Calif.	5
	$\frac{1}{2}\frac{9}{}\ \frac{5}{2}$	19.5.2	Vesuvius	4
	63	631	Monzoni, Tyrol	3
	84	841	Vesuvius	4
	75	751	"	4
	$2\frac{8}{5}$	10.8.5	"	4
	$\frac{5}{2}2$	542	"	4

1.—J. Boecker, 1892, Zeitschr. f. Kryst., XX, p. 225.
2.—M. Weibull, 1895, Zeitschr. f. Kryst., XXV, p. 1.
3.—H. Buttgenbach, 1898, Ann. Soc. Géol. Belg., XXV, p. 106.
4.—A. Rosati, 1910, Rend. Accad. Linc., XIX, (2). p. 75.
5.—A. S. Eakle, 1917, Univ. Calif. Pub. (Geol.), X, p. 338.

Vilatéite

a: b: c = 1.69581:1:0.88864 $\beta = 89° 27'$

c	0	001	La Valate, Haute Vienne, France			1
b	0∞	010	"	"	"	1
m	∞	110	"	"	"	1
e	01	011	"	"	"	1
o	30	301	"	"	"	1
u	—31	$\bar{3}11$	"	"	"	1
θ	—34	$\bar{3}41$	"	"	"	1

1.—A. Lacroix, 1910, Min. de France, IV, p. 477.

Vivianite

	$\frac{3}{2}\infty$	320	Leadville, Colo.		2
	$\frac{5}{4}\infty$	540	"	"	2
h	$\infty\frac{5}{2}$	250	Tatasi, Bolivia		1
	$\infty 3$	130	Tasna, Bolivio		1
	$\infty 4$	140	"	"	1
	14.0	14.0.1	Leadville, Colo.		2
	$-\frac{3}{2}0$	$\bar{3}02$	"	"	2
	$-\frac{5}{2}0$	$\bar{5}02$	"	"	2
	$-1\frac{3}{8}$	$\bar{8}38$	Tasna, Bolivia		1

1.—L. J. Spencer, 1907, Min. Mag., XIV, p. 324.
2.—H. Ungemach, 1912, Ann. Soc. Géol. Belg., Mém., XXXIX, p. 6.

Vrbaite

a: b: c = 0.5659:1:0.4836

c	0	001	Allchar, Macedonia		1
a	$\infty 0$	100	"	"	1
b	0∞	010	"	"	1
f	$0\frac{3}{5}$	035	"	"	1
e	02	021	"	"	1
d	04	041	"	"	1
q	$\frac{1}{2}$	112	"	"	1
p	1	111	"	"	1
o	3	331	"	"	1
r	13	131	"	"	1

1.—B. Jezek, 1912, Zeitschr. f. Kryst., LI, p. 365.

Wavellite

a: b: c = 0.55774:1:0.4572

	3∞	310	Montbras, Creuse, France	1
	$\frac{3}{2}\infty$	320	Cly, York Co., Pa.	1
	$\frac{4}{3}\infty$	430	" " "	1

1.—H. Ungemach, 1912, Bull. Soc. fr. Min., XXXV, p. 536.

Wellsite

a: b: c = 0.678:1:1.245 $\beta = 53° 27'$

c	0	001	Buck Creek, Clay Co., N. C.	1
a	$\infty 0$	100	" " " "	1
b	0∞	010	" " " "	1
m	∞	110	" " " "	1

1.—J. H. Pratt and H. W. Foote, 1897, Amer. Journ. Sci., III, p. 443.

Whewellite

a	$\infty 0$	100	Burgh (Dux), Bohemia	1
	$\frac{5}{4}\infty$	540	Urbeis, Alsace, France	3
n	$\infty\frac{9}{7}$	790	Schlan, Bohemia	2
	$\infty\frac{7}{4}$	470	Urbeis, Alsace, France	3
ν	$\infty\frac{5}{2}$	250	Freiberg and Zwickau, Saxony	1
F	$\infty 9$	190	Kopitz, Bohemia	4
O	$0\frac{1}{3}$	013	Burgh, (Dux), Bohemia	4
d	$0\frac{3}{2}$	032	" " "	1
α	03	031	" " "	1
N	$\frac{2}{3}0$	203	" " "	4
μ_1	$\frac{5}{7}0$	507	Schlan, Bohemia	2
ε	$-\frac{1}{4}$	$\bar{1}14$	Freiberg, Saxony	1
g	1	111	Burgh (Dux), Bohemia	1
	-1	$\bar{1}11$	Urbeis, Alsace, France	3
H	$1\frac{7}{5}$	575	Kopitz, Bohemia	4
	12	121	Urbeis, Alsace, France	3
β	13	131	Burgh (Dux), Bohemia	1
γ	$\frac{1}{2}1$	122	" " "	1
η	21	211	Zwickau, Saxony	1
s	-21	$\bar{2}11$	" "	1
δ	$\frac{1}{4}\frac{3}{8}$	238	Burgh (Dux), Bohemia	1
B	34	341	" " "	1
	$\frac{3}{2}2$	342	Urbeis, Alsace, France	3
	$\frac{1}{2}\frac{5}{8}$	458	" " "	3

S	$\frac{5}{8}\ \frac{5}{16}$	10.5.16	Burgh, (Dux), Bohemia			4
T	$\frac{4}{3}\ \frac{2}{3}$	$42\bar{3}$	"	"	"	4
Q	$-\frac{3}{17}\ \frac{7}{17}$	$\bar{3}.7.17$	"	"	"	4
V	$-\frac{3}{8}\ \frac{5}{8}$	$\bar{3}58$	"	"	"	4
C	—65	$\bar{6}51$	"	"	"	1
R	$-\frac{3}{10}\ \frac{9}{40}$	$\bar{1}\bar{2}.9.40$	"	"	"	4
A	—32	$\bar{3}21$	"	"	"	1

1.—F. Kolbeck and V. Goldschmidt, 1908, Centralbl. f. Min., p. 659.
2.—F. Slavic, 1909, Abh. d. böhm. Akad., XIV.
3.—H. Ungemach, 1909, Bull. Soc. fr. Min., XXXII, p. 20.
*4.—B. Jezek, 1911, Abh. d. böhm. Akad., XVI, No. 2, p. 9.

Wilkeite

Hexagonal $a:c=1:0.730\pm$

$\infty 0$	$10\bar{1}0$	Crestmore, Riverside Co., Calif.		1
∞	$11\bar{2}0$	"	"	"	1
10	$10\bar{1}1$	"	"	"	1

1.—A. S. Eakle and A. F. Rogers, 1914, Amer. Journ. Sci., XXXVII, p. 262.

Willemite

$a:c=1:0.6679$

h	3∞	$31\bar{2}0$	Franklin Furnace, N. J.			1
	$\frac{5}{2}\infty$	$52\bar{7}0$	Musartut, Greenland			2
z	—10	$01\bar{1}1$	Merritt Mine, New Mex.			1
n	—20	$02\bar{2}1$	Franklin Furnace, N. J.			3
s	$\frac{1}{3}$	$11\bar{2}3$	"	"	"	1
u	$\frac{1}{3}$	$2\bar{1}\bar{1}3$	Merritt Mine, New Mex.			1
x	21	$31\bar{2}1$	Franklin Furnace, N. J.			1
i	43	$43\bar{7}1$?	"	"	"	3
j	34	$34\bar{7}1$	"	"	"	3
v	$-\frac{2}{5}\ \frac{1}{5}$	$\bar{1}32\bar{5}$	"	"	"	1
d	$-1\frac{1}{2}$	$12\bar{3}2$	"	"	"	3
D	$-1\frac{1}{2}$	$\bar{1}32\bar{2}$	"	"	"	3
k	$-\frac{3}{2}\ \frac{1}{2}$	$13\bar{4}2$	"	"	"	3
q	—31	$13\bar{4}1$	"	"	"	3
o	$-\frac{4}{3}\ \frac{1}{3}$	$14\bar{5}3$	"	"	"	3
l	—51	$15\bar{6}1$	"	"	"	3

1.—S. L. Penfield, 1894, Amer. Journ. Sci., XLVII, p. 305.
2.—O. B. Böggild, 1905, Min. Grönland, p. 180.
3.—C. Palache, and R. P. D. Graham, 1913, Amer. Journ. Sci., XXXVI, p. 639.

Wolframite

v	$-\frac{1}{2}1$	$\bar{1}22$	Tonopah, Nev.	1

1.—A. S. Eakle, 1912, Univ. Cal. Pub., (Geol), VII, p. 19.

Wollastonite

l	$\frac{7}{4}\infty$	740	Crestmore, Riverside Co., Calif.	1
m	$\infty\frac{1}{4}$	140	" " "	1
τ	$\frac{1}{4}0$	104	" " "	1
θ	$-\frac{1}{4}0$	$\bar{1}04$	" " "	1
p	1	111	" " "	1
$\mathfrak{p}$	$\frac{7}{4}1$	744	" " "	1
o	$\frac{3}{4}1$	344	" " "	1
n	$\frac{1}{4}1$	144	" " "	1
u	$-\frac{1}{4}1$	$\bar{1}44$	" " "	1
i	$-\frac{3}{4}1$	$\bar{3}44$	" " "	1
$\mathfrak{d}$	$-\frac{7}{4}1$	$\bar{7}44$	" " "	1
ω	$\frac{1}{2}2$	142	" " "	1
ϵ	$-\frac{1}{2}2$	$\bar{1}42$	" " "	1

1.—A. S. Eakle, 1913, Univ. Cal. Pub., (Geol), X, p. 334.

Wulfenite

p	—20	$\bar{2}01$	Jarilla Mts., Doña Ana Co., N. Mex.	1
θ	$\frac{1}{12}$	1.1.12	Loudville, Mass.	2
γ	$\frac{3}{4}$	443	" "	2
π	$1\frac{1}{3}$	313	Jarilla Mts., Doña Ana Co., N. Mex.	1
λ	13	131	Loudville, Mass.	2
	$\frac{1}{15}$ $\frac{1}{75}$	5.1.17	Val Seriana, Italy	3

1.—C. A. Ingersoll, 1894, Amer. Journ. Sci., XLVIII, p. 193.
2.—B. K. Emerson, 1895, U. S. Geol. Surv., Bull. CXXVI, p. 176.
3.—E. Artnini, 1896, Riv. Min. Ital., XVI, p. 25.

Wurtzite

	$\frac{7}{4}0$	$70\bar{7}4$	Nordmark, Sweden 1

1.—G. Flink, 1908, Ark. Kemi. Min. Geol., III, No. 11, p. 20.

Xanthoconite

$a:b:c = 1.9187:1:1.0152 \quad \beta = 88° 47'$

c	0	001	Freiberg, Saxony, Germany	1
a	$\infty 0$	100	" " "	1
m	∞	110	" " "	1

n	$0\frac{5}{3}$	053	Freiberg, Saxony, Germany			1
f	$\frac{3}{2}0$	302	St. Kreuz, Lebertal, Alsace, France			2
D	50	501	Freiberg, Saxony, Germany			1
d	—50	$\bar{5}01$	"	"	"	1
e	—2	$\bar{2}01$	St. Kreuz, Lebertal, Alsace, France			2
f	$\frac{1}{5}$	115	Freiberg, Saxony, Germany			1
r	$\frac{1}{2}$	112	"	"	"	1
t	$\frac{2}{3}$	223	"	"	"	1
h	$\frac{3}{4}$	334	"	"	"	1
p	1	111	"	"	"	1
y	$\frac{4}{3}$	443	"	"	"	1
ρ	$\frac{3}{2}$	332	"	"	"	1
q	5	551	"	"	"	1
Q	—5	$\bar{5}51$	"	"	"	1
Y	$-\frac{4}{3}$	$\bar{4}43$	"	"	"	1
P	—1	$\bar{1}11$	"	"	"	1
R	$-\frac{1}{2}$	$\bar{1}12$	"	"	"	1

1.—H. A. Miers, 1893, Min. Mag., X, p. 185.
2.—H. Bücking, 1913, Mitth. d. geol. Land. Els.-Lothr., VIII, p. 201.

Zincite

o	$\frac{2}{3}0$	$20\bar{2}3$	Franklin Furnace, N. J.			1
α	$\frac{4}{5}0$	$40\bar{4}5$?	"	"	"	2
β	$\frac{5}{4}0$	$50\bar{5}4$?	"	"	"	2

1.—P. Grosser, 1892, Zeitschr. f. Kryst., XX, p. 354.
2.—A. J. Moses, 1895, School of Mines Quar., XVI, p. 226.

Zinkenite

c	0	001	Wolfsberg, Harz, Germany			1
a	$\infty 0$	100	"	"	"	1
ϵ	$\frac{1}{2}0$	102	"	"	"	1

1.—L. J. Spencer, 1897, Min. Mag., XI, p. 188.

Zinnwaldite

	$0\frac{1}{7}$	017	Narsarsuk, Greenland			1
	$-\frac{1}{11}$	$\bar{1}.1.11$	"	"		1
	$-\frac{1}{4}$	$\bar{1}14$	"	"		1
	—2	$\bar{2}21$	"	"		1

1.—G. Flink, 1898, Medd. om Grönland, XIV, p. 232.

Zircon

w	50	501	Ilmen Mts., Russia		1
u	70	701	"	"	1
ρ	$1\frac{4}{5}$	545	"	"	1
r	$\frac{7}{6}1$	766	"	"	1
π	$2\frac{4}{3}$	643	"	"	1

1.—P. Jeremejew, 1895, Verh. Russ. Min. Ges., XXXIII, p. 429.

Zirkelite

Hexagonal $a:c=1:1.1647$

c	0	0001	Sabaragamuwa, Ceylon		1
m	∞	$10\bar{1}0$	"	"	1
d	$\frac{1}{2}0$	$10\bar{1}2$	"	"	1
e	$\frac{2}{3}0$	$20\bar{2}3$	"	"	1
r	10	$10\bar{1}1$	"	"	1
s	20	$20\bar{2}1$	"	"	1

1.—G. F. Herbert-Smith, 1913, Min. Mag., XVI, p. 309.

Zoisite

g	5∞	510	Chester, Mass.		1
h	4∞	410	"	"	1
i	$\frac{9}{5}\infty$	950	"	"	1
j	$\frac{5}{4}\infty$	540	"	"	1
	$0\frac{3}{2}$	032			2
y	2	221	Chester, Mass.		1
A	$1\frac{1}{2}$	212	"	"	1
	$1\frac{7}{4}$	474			2
B	14	141	Chester, Mass.		1

1.—C. Palache, 1908, Zeitschr. f. Kryst., XLIV, p. 20.
2.—J. Schetelig, 1913, Norsk. Geol. Tidsskrift., II, (3) , p. 38.

59.57,92(79.4)

Article III.—NEW PACIFIC COAST CYNIPIDÆ (HYMENOPTERA)[1]

By Alfred C. Kinsey

Plate XXIV

During 1919 and 1920, while a Sheldon Travelling Fellow of Harvard University, I had an opportunity to make a considerable collection of Pacific Coast gall-wasps. The new species and varieties of this paper constitute only a small part of the undescribed material in the collection. It is safe to say that not fifty per cent of the Pacific Coast gall-making Cynipidæ have yet been reported. This will not appear strange when it is realized that the region constitutes a very distinct faunal area and that, with the exception of Miss Rose Patterson's rather small collection made mostly about Stanford University (and studied by Fullaway), there are no published accounts of systematic collecting of Cynipidæ from the region.

Generic names in this paper follow the scheme I have used before: "*Andricus*" is a meaningless name and does not necessarily express natural relationships of the species thus labelled; other generic names used appear to designate truly phylogenetic groups.

Acknowledgment of aid in my work with Pacific Coast Cynipidæ is due the Harvard University authorities and especially Dr. William Morton Wheeler, of the Bussey Institution of Harvard University, to whom I am indebted for the Fellowship which made the collecting trip possible; to Mr. S. B. Parish, then of San Bernardino, California, for material help in learning to distinguish California plants, particularly oaks; and to Mr. W. H. Vance who has assisted in the tedious but all-important work of mounting my material for study.

The holotypes of all these species are in The American Museum of Natural History; paratypes are in that museum and elsewhere as indicated for each species. All specimens of these species labelled cotypes should be considered paratypes.

Andricus atrimentus, new species

Plate XXIV, Figures 15 and 16

Black; thorax largely smooth; median, anterior parallel, and lateral lines absent; arcuate groove at base of scutellum; female abdomen produced dorsally, male abdomen small, pedicellate; areolet moderately small.

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[1]Contribution from the Zoological Laboratory of Indiana University, No. 185 (Entomological No. 1).

Female.—Head: Not quite as wide as thorax, hardly widened behind the bulging eyes; black, mouth-parts bright piceous; coriaceous, finely rugose and scatteringly hairy on the face. Antennæ brown, yellowish basally; densely hairy except on the first two segments; 14 (?)-jointed; third segment not much longer than fourth. Thorax: Piceous black to black; smooth and shining, only microscopically coriaceous anteriorly and laterally; parapsidal grooves deep, continuous to the pronotum, gradually diverging anteriorly, gradually converging toward the scutellum; median groove lacking; anterior parallel lines and lateral lines practically lacking; scutellum black, elongate, rugose, hairy, an arcuate depression at the base, deep, smooth, not forming foveæ; pronotum piceous black, rugose, rugoso-aciculate laterally; mesopleuræ black, rugose, very sparsely hairy, aciculate, the central area smoother, shining. Abdomen: Piceous black; smooth and shining, microscopically punctate, sparingly hairy at the base laterally; produced dorsally, the second segment covering about half the area, segments two to four with the edges at an angle of 45°; ventral spine short, lighter in color, sparsely hairy; ventral valves hairy, at a 45° angle. Legs: Yellow-brown, the coxæ piceous, the tips of tarsi brown; tarsal claws simple. Wings: Clear, minutely hairy, ciliate on margin; veins brown, subcosta, radius, and basalis heavy; areolet moderately small; cubitus hardly reaching basalis; radial cell long and narrow, open, the second abscissa of the radius straight, the first abscissa slightly angulate, without a projection, slightly infuscated. Length: 2.0–2.5 mm.

Male.—Differs from the female as follows: antennæ entirely brown, 15-jointed; thorax more elongate; abdomen very small, narrow, rather long-pedicellate; legs darker brown.

Galls (Pl. XXIV, Figs. 15, 16).—Small, inflated capsules in the leaf-blade. Monothalamous. Spherical, 3.–5. mm. in diameter, about smooth, leaf-green when fresh, soon paling, finally drying yellow-brown. Walls thin, a thin-walled larval cell, about 1.5 mm. in diameter, is connected with the outside wall by a tangle of dense, but not definitely branched fibers. In the leaf-tissue, projecting about equally on either side, usually near the edge of very young leaves of *Quercus Douglasii*.

Range.—California: Three Rivers, Redding.

Types.—Five females, six males, thirty-eight galls, labelled Three Rivers, California; March 23, 1920; Kinsey collector. The adults are all imperfect. Holotype female and paratype adults and galls in the collections of The American Museum of Natural History; paratype adults in the collection of the author; galls at Leland Stanford University and the U. S. National Museum.

These galls develop early on the unfolding leaves, looking like small air-bubbles blown in the tissue. The galls were always very new and fresh when gathered, but were also practically mature. The development of this generation of the species must be a matter of only a month or two; the other generation is unknown. The adults were maturing, had not emerged, but did emerge at some date later than the dates of collecting the galls: March 23 at Three Rivers, and April 2 at Redding. Of 23 adults, 13 were females. This species resembles *Andricus palustris* form *palustris* (Osten Sacken) of the black oaks of the eastern part of the United States, and it might prove desirable to consider the two as varieties of one species. Morphologically the two are very similar, even

in many minute details of venation, thoracic sculpture, abdominal and antennal characters; in *atrimentus* the parapsides are more convergent at the scutellum, the scutellum is less elongate, less rugose, with the foveal groove smoother and less distinctly bifoveate than in *palustris*. In the male of *atrimentus* the abdomen is not as small as in *palustris*. *Atrimentus* occurs on a white oak in one distinct faunal area; *palustris* on black oaks in a very different faunal area. It is exceedingly significant that the galls of the two species show similarity of structure, for as has been repeatedly shown the gall is an expression of the physiological nature of the insect. Physiologically then the two species are related, just as they are morphologically, but physiologically they differ even more markedly than morphologically. For though the galls are similar hollow bladders in the leaf, the Pacific Coast species does not have the thick and succulent walls of *palustris;* while the attached larval cell of *atrimentus* is distinctly unlike the remarkable, loose cell of *palustris*. Both forms are bisexual generations, developing very quickly in early spring on the unfolding leaves. The other generation of *palustris*, namely *Andricus palustris* form *compressus* (Gillette), is a wingless, agamic species forming a small, hollow, egg-shaped, separable gall on the leaves in late summer, the gall dropping to the ground in autumn, the insect emerging very early in the spring. It is not unlikely that *atrimentus* has a similar history, but it will be important that some one determine exactly what differences exist in the life-histories of the two insects.

Andricus attractans, new species

Plate XXIV, Figure 2

Male.—Black; parapsides and lateral grooves the only well-developed thoracic grooves; foveæ irregular, not distinctly separated; legs rufous yellow; areolet moderate in size; length averaging 2.0 mm. Head: At least as wide as the thorax, the eyes large, bulging beyond the sides of the head; piceous black, toward the mouth and on the mouth-parts more piceo-rufous; very finely rugose, very finely and sparsely hairy. Antennæ light yellow-brown, golden yellow basally, pubescent, 15-jointed, the last segment not shorter than the preceding, the third segment approaching twice the length of and more slender than any other. Thorax: Elongate; piceous black to black; posteriorly about smooth, mostly finely coriaceous antero-laterally; parapsidal grooves distinct, less so anteriorly, gradually and then widely divergent anteriorly, gradually convergent posteriorly, but still fairly well separated; median groove absent; anterior parallel lines hardly indicated; lateral lines not very well defined; scutellum narrow, longer than wide, slightly hairy, rugose, depressed and smoother anteriorly but with the two irregular and slightly rugose foveæ not distinctly separated by the rugose intermediate area; pronotum rugose, more rugoso-aciculate posteriorly; mesopleuræ in part smooth and shining, irregularly aciculate

or punctate in places. Abdomen: Small, long-pedicellate, irregularly triangular, piceous to black, lightest at the posterior tip, apparently smooth and naked. Legs: Rufous yellow, light piceous on the coxæ, tips of tarsi darker; tarsal claws simple. Wings: Large, extending more than half beyond the abdomen; finely set with hairs, margins ciliate; veins light brown, cross-veins and subcosta darker; areolet moderate in size; cubitus faint, reaching the basalis at the mid-point, but hardly evident there; radial cell open; second abscissa of the radius almost straight, the first abscissa slightly arcuate without a projection. Length: 1.7–2.2 mm.

Galls (Pl. XXIV, Fig. 2).—Sticky cells protruding from buds. Each cell is monothalamous, about 2×3 mm., oval, but with rather flattened ends; only microscopically roughened, marbled red to dark green when fresh, drying brown; thin-walled, hollow. Under the bud scales, but often largely protruding; covered with a sticky secretion when fresh; often several in a bud; on *Quercus Wislizeni*.

Range.—California: Redding.

Types.—Thirteen males and nine infested buds. Holotype male and paratype males and galls in the collections of The American Museum of Natural History; paratype males and galls in the collections of Leland Stanford University, the U. S. National Museum, and of the author. Labelled Redding, California; April 2, 1920; Kinsey collector. Most of the insects are partly imperfect.

These galls are distinct in appearance from other Pacific Coast bud galls, but probably reach maturity in such a short time that they will need to be discovered at just the opportune season. The very sticky secretion on the surface proves attractive to ants, and likely attracts wasps and bees. I am surprised to find all of the thirteen adults bred are males, and am at a loss to explain the situation. The insect shows relations to some species of *Neuroterus*, but does not belong to the typical group of that genus.

Andricus gigas, new species

Plate XXIV, Figure 14

Entirely piceous black; mesothorax almost smooth; parapsidal grooves the only thoracic lines; a distinctly smooth, shining area on the hairy scutellum; areolet small or closed, cubitus discontinuous.

Female.—Head: About as wide as thorax, hardly broadened behind the eyes; black, mandibles rufous brown; finely coriaceous, face smooth but sparingly and minutely punctate, sparsely and finely hairy on the sides of the head and on the face. Antennæ finely hairy, brown, the basal three or four segments yellowish brown, 14(?)-jointed, third segment longest, but hardly longer than the fourth. Thorax: Piceous to black, mesothorax mainly smooth and shining, coriaceous anteriorly; parapsidal grooves fine but evident only posteriorly, less evident, discontinuous or absent anteriorly where the area is finely coriaceous; median groove, anterior parallel and lateral lines lacking; scutellum finely rugose, hairy, with a small, elevated, smooth and naked area at the apex; foveal depression arcuate, shallow and smooth; pronotum smooth and naked, sparingly hairy on the dorsal edge, slightly furrowed posteriorly; mesopleuræ mostly smooth and naked, limitedly furrowed centrally. Abdomen: Piceous black, ventral spine yellow-piceous; smooth and shining, naked

of hairs except for a few hairs on the ventral spine and tips of valves, and scattering hairs at the base of the second segment; abdomen produced dorsally, segments two to four with their ventral edges considerably rounded, segment two occupying about half the area; valves at about a 45° angle. Legs: Yellow-brown, femora especially of the hind legs darker, coxæ piceous brown, tips of tarsi dark; finely and not densely hairy; tarsal claws simple. Wings: Clear, set with fine, brown hairs, edges ciliate; veins brown; areolet moderately small to closed; cubitus very fine, not reaching basalis; radial cell long and open, but the second abscissa of radius somewhat curved; first abscissa with only a suggestion of an angle, without a projection. Length: 1.5–2.0 mm.

Male.—Differs from the female as follows: antennæ entirely brown, 15 (?)-jointed; abdomen very small, moderately long-pedicellate; areolet averaging smaller; length uniformly near 1.5 mm.

Galls (Pl. XXIV, Fig. 14).—Small, brown, egg-shaped cells scattered in the aments. Each cell monothalamous, naked, only microscopically granulate, well pointed at the apex, thin-walled and hollow. Apparently tremendously enlarged anthers, about 1 mm. in diameter by 2 mm. long. Scatteringly in aments of *Quercus Douglasii*.

Range.—California: Merced Falls.

Types.—Thirteen females, seven males and over 150 galls. Holotype female and paratype females, males, and galls in The American Museum of Natural History; paratype adults and galls in Leland Stanford University, the U. S. National Museum, and the author's collection. Labelled Merced Falls, California; March 28, 1920; Kinsey collector. All of the adults are imperfect.

The galls were just maturing on March 28. Because of the location and structure of the galls, this form of the insect must complete its history in a month or two; there is undoubtedly an alternate generation, probably agamic.

Andricus humicola, new species

Plate XXIV, Figure 13

Female.—Bright rufous brown; thorax hairy, lateral lines in a smooth area, parapsidal grooves rugose anteriorly, foveæ very rugose, areolet large, claws simple. Head: Bright rufous brown, the moderately narrow median elevation and the mouth-parts darker; about as wide as the thorax, considerably widened behind the eyes; rugoso-punctate, the cheeks more distinctly coriaceous and punctate, whole head moderately hairy. Antennæ darker rufous brown; the second joint almost globular, the third joint longest, as long as one and two combined, fourth two-thirds the length of three. Thorax: Generally bright reddish brown; coriaceous and scatteringly punctate and hairy, especially anteriorly, on the sides, and on the pronotum; parapsidal grooves extending to the pronotum, fairly broad, deep, and smooth for two-thirds the distance, anteriorly finer, rugose, and widely divergent, gradually convergent and not widely separated posteriorly; median groove very fine posteriorly, merely indicated by a more rugoso-punctate depression anteriorly; anterior parallel lines extending about half-way toward the scutellum, somewhat raised and smooth; lateral lines extending more than half the length of the mesonotum, in an area somewhat darker in color, elevated, smooth and shining; scutellum rufous to black, longer than wide, rugose, hairy, with two large sunken areas basally indicating very rugose

foveæ; mesopleuræ bright rufous, darker toward the tegulæ and ventrally, shining, partly smooth, mostly puncto-aciculate, hairy. Abdomen: Rufous to bright piceous; smooth, only microscopically punctate, sparingly hairy on the sides basally, and on the ventral spine and valves; as broad or broader than long, the second segment covering only somewhat more than half the area, extending only somewhat farther dorsally, the ventral edges of the segments moderately curved; ventral spine fairly long and slender, ventral valves at an angle of 60°. Legs: Rufous, darker to black on the trochanters and hind tibiæ and tarsi; punctate and hairy, most densely so on the tibiæ and tarsi; tarsal claws simple. Wings: Clear, set with fine hairs, margin ciliate; veins brown, distinct; areolet moderately large; cubitus fading out before reaching the basal vein; radial cell open, tip of radius showing some remnant of the subcosta, the first abscissa of the radius angulate, the projection into the radial cell blunt and not prominent, the vein somewhat infuscated. Length: 4.2 mm.

Gall (Pl. XXIV, Fig. 13).—Large, irregular, tuber-like, woody swellings of the bark and new wood of roots. Agglomerate. The swellings are very irregular, smooth and rounded when fresh, roughening with age; the fresh bark covering is more reddish brown than on the normal roots; length up to 10.5 cm., the diameter 7.5 cm. on large galls. Affecting both wood and bark, including wood below the normal line of the bark; larval cells lying toward the bark, oval, 3.5 by 4.5 mm., with a thin, distinctive tissue lining the cells, but not separable from the wood. On the sides of large roots, well below the surface of the ground, on *Quercus Kelloggii.*

Range.—Oregon: Ashland.

Types.—Holotype female and seven paratype galls; female and galls at The American Museum of Natural History; galls at Leland Stanford University, the U. S. National Museum, and in the author's collection. Labelled Ashland, Oregon; April 6, 1920; Kinsey collector.

A cave-in of a railroad embankment had exposed these galls. The single female was found running over the surface of the galls, and was identified as the producer of these by recovering an immature adult which had not emerged from the galls. Almost all of the insects had emerged, but at least one was still alive on April 6. Very likely the species is agamic, at least in this generation.

Andricus pedicellatus, new species

Plate XXIV, Figure 10

Mostly black, except the brownish-yellow legs; entire thorax except scutellum smooth, shining, and naked; parapsides the only apparent grooves; veins brown, areolet small.

Female.—Head: Not quite as broad as the thorax, only slightly widened behind the eyes; black, mouth-parts brownish rufous; rugoso-granulose, most rugose on the front, very sparingly hairy, rather densely hairy on the lower part of the face; antennæ brownish rufous at base. Thorax: Entirely black; mesothorax elongate; smooth and shining, slightly coriaceous anteriorly, naked; parapsidal grooves distinct, continuous to the pronotum, curved apart anteriorly, gradually and rather closely convergent at the scutellum; median groove lacking; anterior parallel and lateral lines only very slightly indicated; scutellum elongate, rounded at the pos-

terior edge, moderately rugose, smoother basally, set with long hairs, a large, broad, sunken, smooth and arcuate furrow at base not divided into foveæ; pronotum almost smooth and shining; mesopleuræ smooth and shining, slightly aciculate in places. Abdomen: Piceous black; entirely smooth and shining except for a very few hairs at the base laterally; somewhat higher than long, highest posteriorly, second segment not covering half the area, segments two to four curved ventrally, only moderately produced dorsally; ventral valves at an angle of more than 60°. Legs: Brownish yellow, coxæ piceous; hairy; tarsal claws simple. Wings: Long, clear, set with fine hairs, margins ciliate, veins brown, subcosta, radius and basalis heaviest; areolet moderately small, cubitus continuous to the basalis but rather faint there; radial cell open, long, and narrow; second abscissa of the radius only slightly curved, the first abscissa slightly angulate, without a projection. Length: About 2.0 mm. (?).

Male.—Similar to the female, differing as follows: eyes large, protruding beyond sides of head; antennæ wholly dark brown; parapsidal grooves less evident, especially anteriorly; abdomen very small, long-pedunculate; legs darker brownish yellow, the femora brownish piceous; areolet very small, the cubitus continuous to the basalis but very faint there. Length: 2.2 mm. One male, apparently not wholly mature, has the thorax and abdomen lighter piceous, the length 1.5 mm.

Galls (Pl. XXIV, Fig. 10).—Small, elongate capsules attached by a slender thread near the edge of the leaf. Monothalamous. The capsule is elongate, 5.–7. mm. long by 1.0–1.5 mm. wide; sharp-tipped but broadest near the tip, basally slender tapered, continuing into a slender, thread-like stem 5.–12. mm. long, evidently a continuation of a vein of the leaf. The capsules are thin-walled and entirely hollow. Attached either near the edge or farther from the edge to very young leaves of *Quercus Douglasii*.

Range.—California: Three Rivers, Oroville.

Types.—Four females, two males, and many galls; holotype female, paratype female, male, and galls in the collection of The American Museum of Natural History; paratype adults and galls in the collection of the author; galls at Leland Stanford University and the U. S. National Museum. Labelled Three Rivers, California, March 23, 1920, and Oroville, California, April 1, 1920; Kinsey collector. The adults are all imperfect, and consequently it seemed desirable to utilize material from two localities in making the description.

This species appears very early in the spring, as soon as small leaves come out of the opening buds. At Three Rivers the galls were just maturing. It is likely that this is the short-lived bisexual generation of a species having an agamic alternate generation which takes all but one or two months of the year to develop. The species is in many respects related to species like *Neuroterus irregularis* (Osten Sacken), *N. majalis* (Osten Sacken), and *N. vesiculus* (Bassett), but those species do not represent typical *Neuroterus* Hartig.

Andricus perdens, new species

Plate XXIV, Figures 5 to 7

Female.—Generally dark rufous, mesothorax shining, obscurely reticulated, hairy; scutellum squared off posteriorly, areolet moderately large, radial area broad. Head: Not as broad as the thorax, considerably broadened behind the eyes; deep rufous, piceous black at the mouth and on the mouth-parts; rugoso-coriaceous, a rugose area between the ocelli, face more rugose, (hairy?). Antennæ hairy, joints one and two piceous black, three and four black, second segment almost globular, very much the smallest, three as long as one and two together and almost twice as long as four. Thorax: Mesothorax deep rufous; appearing smooth and shining, finely reticulated, moderately punctate and hairy, more densely punctate and hairy anteriorly; parapsidal grooves continuous to pronotum, narrow, distinct, divergent anteriorly, curved and convergent at the scutellum where they are only narrowly separated; median groove only evident, but is evident for the length of the mesonotum; anterior parallel lines hardly evident for less than half the length of the mesonotum; lateral lines indicated by a smooth area; scutellum rufous-piceous, piceous black at base, somewhat longer than wide, widest near the posterior end, abruptly squared off posteriorly, rugose, dense with long hairs, two basal foveæ broad, deep, shining, smooth, set at a 90° angle; pronotum rufous-piceous, about black at the edges, rugose, dense with long hairs; mesopleuræ rugoso-aciculate and hairy at top and bottom, a large smooth, shining and (apparently) naked area centrally. Abdomen: Rufous, rufous-piceous dorsally and basally, smooth and shining, hairy at the base laterally, (posterior segments hairy?); higher than long, more extended dorsally, edges of basal segments curved ventrally but segments not "tongue-shaped"; second segment occupying about half the area; ventral spine darker rufous, hairy, extended into quite a long, slender, fine-tipped spine; ventral valves piceous black, at a 60° angle. Legs: Brown-black, the coxæ and at least the front tibiæ in part rufous; densely punctate and hairy; tarsal claws well developed, not toothed. Wings: Clear, set with fine hairs, ciliate on edge; veins rufous brown, subcosta, radius and basalis heaviest; areolet moderately large; cubitus just continuous to the basalis but faint there; radial cell open, broad, subcosta stopping quite a little short of the margin; second abscissa of the radius somewhat curved; the first abscissa somewhat angulate but without a projection. Length: 3.0 mm.

Galls (Pl. XXIV, Figs. 5–7).—Stem swellings, raggedly split open, containing flattened seed-like cells. The swellings are 6.–13. mm. in diameter by 1.5–20. cm. long. Within are large cavities, 4 or 5 arranged more or less radially about the axis of the stem, and a great many in series along the stem, each cavity sector shape, extending to the bark, 10. mm. wide or less at the edge. Inserted on the wall of each cavity is a larval cell; each cell is monothalamous, flattened, a somewhat squared oval in outline, 4. mm. high by 3. mm. wide, broadest at the top; concave at the base with a projecting tongue by means of which the cell is inserted in the twig; cells smooth, shining, buff-yellowish, finely streaked, more or less, with purplish brown. The cell walls are shell-like, moderately thick, entirely hollow within. At maturity the bark splits raggedly over each cavity, the larval cell drops to the ground, and the affected twigs die. On terminal twigs of *Quercus Kelloggii.*

Range.—Oregon: Ashland and Grants Pass. California: Gilroy (Redwood School), Placerville and Ukiah.

Types.—Two females (imperfect and not completely mature), 12 larval cells and 26 infested twigs. Holotype female and galls in the collections of The American Museum of Natural History; paratype female and galls with the author; galls at Leland Stanford University and the U. S. National Museum. Labelled Ashland, Oregon; April 6, 1920; *Q. Kelloggii;* Kinsey collector.

This is a very common cynipid throughout the Pacific Coast region, its presence being made noticeable because the leading shoots and ultimately the whole tree may be killed. I have seen small stands of young black oaks, possibly fifteen years old, almost completely killed out in this way. It has, however, been difficult to obtain the wasp, apparently because the larval cells fall out of the twigs before maturity; possibly the insect completes development and emerges only after it has been on the ground for some time. From galls collected from January through April no adults were obtained, and only two individuals which had failed to quite complete development were cut out of the few larval cells remaining in the twigs. A very similar if not specifically identical gall is found on *Quercus Wislizeni.*

Andricus perfoveatus, new species

Plate XXIV, Figure 8

Female.—Antennæ wholly deep brown, 15-jointed; median groove distinct, scutellum roughly sculptured; mesopleuræ with a large aciculate area; cubitus continuous to basalis; tarsal claws simple. Head: About as wide as the thorax; hardly widened behind eyes; black, mandibles rufous brown; roughly coriaceous-rugose, rugose and somewhat hairy on the face. Antennæ densely hairy; the third joint not much longer than the fourth, the fifteenth not much shorter than the fourteenth. Thorax: Entirely black; mesonotum roughly coriaceous, almost naked of hairs; parapsidal grooves distinct, wider posteriorly, continuous to the pronotum where they diverge sharply, moderately convergent at the scutellum where they are much broader; median groove wide at the scutellum, distinct for less than half the length of the mesothorax, but indicated by a slightly rugose depression anteriorly; anterior parallel lines scarcely indicated; lateral lines indicated only by a smoother area; scutellum much longer than wide, roughly but not deeply sculptured, with the two large, deep, shining foveæ at the base somewhat sculptured, and separated by rougher sculpturing; metanotum hairy only at the sides; pronotum roughly aciculate or sculptured laterally, sparsely hairy only on the edge; mesopleuræ almost smooth and shining, very sparsely hairy, with a large, central, aciculate area. Abdomen: Piceous to black, lightest ventrally, entirely smooth and shining, very scatteringly hairy laterobasally, on the posterior edge, and on the ventral spine and valves; about as wide as long, produced dorsally, the ventral edges of segments two to four well rounded, the hypopygium somewhat produced, the valves at about a 60° angle, second segment occupying about half the abdominal area. Legs: Somewhat hairy, yellow-brown, the coxæ, trochanters, and tips of tarsi dark brown; tarsal claws simple. Wings: Clear, finely hairy, ciliate, veins deep brown; areolet moderately small; cubitus reaching the basalis; radial cell open; second abscissa of radius not quite straight,

extending slightly along the margin; first abscissa distinctly angulate but without a projection, and slightly infuscate where it joins the subcosta. LENGTH: 1.5–2.2 mm., averaging nearer 2.2 mm.

GALLS (Pl. XXIV, Fig. 8).—Small, fleshy-walled capsules imbedded in the leaf-blade. Monothalamous. Spherical or more elongate, about 6. mm. in diameter (perhaps larger when fresh), leaf-green, drying brown, projecting about symmetrically from either surface of the leaf. The walls are thick, succulent, the cavity (in shriveled galls) about oval, 2.×3. mm., with a distinct larval cell lining, but the cell inseparable (at least in the shriveled gall). On the very young leaves of *Quercus Kelloggii.*

RANGE.—California: Santa Rosa and Redding.

TYPES.—Six females and twenty galls; holotype female, paratype females, and galls in The American Museum of Natural History; paratype females and galls in the author's collection, and galls at Leland Stanford University and the U. S. National Museum. Labelled Santa Rosa, California; March 16, 1920; Kinsey collector. Some of the adults were cut from old galls and are imperfect.

At the time the galls were collected they were very fresh and succulent, on the very young, unfolding leaves of the black oaks, but inasmuch as adults emerged from some of these galls, in spite of their immediate shriveling on collecting, it would appear that the insects complete their development in a very short period in the early spring. Such species of cynipids are usually bisexual, so the male may yet be discovered for this species.

Andricus serricornis, new species

Plate XXIV, Figure 3

FEMALE.—Thorax almost smooth, rufo-piceous; abdomen piceous; antennæ yellow to brown, rather serrate; parapsidal grooves distinct, other thoracic grooves lacking; areolet small. HEAD: Not quite as wide as the thorax, broadened slightly behind the eyes, a prominent median elevation; piceous or black, mouth-parts brown; finely shagreened or coriaceous, the face sparingly hairy. Antennæ short, brown, darker distally, yellow on four or five basal joints; slightly hairy, the second segment short, almost globose, the third longest and most slender, the last almost twice as long as the preceding; 14-jointed, the last ten joints giving a rather serrate appearance to the antennæ. THORAX: Mesothorax rufo-piceous; almost smooth, very finely coriaceous with a very few scattering hairs especially on the edges; parapsidal grooves distinct, deep, continuous to the pronotum, slightly divergent and finally curved apart anteriorly, slightly convergent posteriorly; median groove lacking or incompletely indicated; anterior parallel lines lacking or barely indicated; lateral lines lacking; scutellum hardly longer than wide, finely rugose, rufo-black, the two basal foveæ broad, shining, not quite smooth, separated by only a fine ridge; pronotum darker rufo-piceous, irregularly aciculate laterally, sparingly hairy; mesopleuræ rufo-piceous, almost smooth and shining, partly irregularly aciculate. ABDOMEN: Piceous black; smooth and shining, very sparingly hairy on the second segment basally; the abdomen produced dorsally, the second segment hardly covering half the area, edges of most of the segments well rounded ventrally; ventral spine lighter in color, slightly hairy; the hypopygium produced slightly; ventral valves at about a

45° angle, hairy. Legs: Yellow-brown except the darker tips of the tarsi; somewhat hairy; tarsal claws simple. Wings: Large, projecting half beyond abdomen, clear, set with fine hairs, edges finely ciliate; veins clear brown, not very heavy; areolet of moderately small or smaller size; cubitus extending hardly two-thirds the distance to the basalis; radial cell open; the first abscissa of the radius almost arcuate with only a suggestion of an angulate form. Length: 1.5–2.2 mm., averaging nearer 2.0 mm.

Male.—Differs from the female as follows: antennæ dark brown only distally, more or less distinctly 15-jointed, more distinctly serrate; thorax wholly yellow-rufous, the scutellum only slightly darker; foveæ divergent, smooth at base; abdomen very small, triangulate, piceous; legs yellow-brown with distal tarsal segments darker; wings with areolet moderately small, small, or closed; length, 1.7 mm.

Galls (Pl. XXIV, Fig. 3).—Dense clusters of grain-like cells, yellow or yellow-brown. Bithalamous, though often several cells will fuse; the whole cluster rounded or elongate-oval, containing 20 to 40 or more cells. The cells are thin-walled, almost wholly hollow except for the partition separating the larval chambers. Apparently modified anthers of aborted, compacted aments, the clusters sessile on the young twigs of *Quercus Wislizeni* and *Q. agrifolia*.

Range.—California: Alpine, Three Rivers.

Types.—Ninety-nine females, 49 males, 12 clusters of galls, labelled Three Rivers, California; March 23, 1920; *Q. Wislizeni;* Kinsey collector. Holotype females, paratype females, males, and galls in the collections of The American Museum of Natural History; paratype adults and galls at Leland Stanford University, the U. S. National Museum, and in the collection of the author.

Galls collected February 24 at Alpine showed the adults to have emerged at an earlier date, but galls collected at Three Rivers on the following March 23 did not give adults until some (unrecorded) later date. It is likely that the emergence dates of spring galls for more northerly latitudes or higher elevations are regularly later. Although I do not have adults from the galls on *Q. agrifolia* the galls appear so identical as to make the identification at least specifically certain. I secured 99 females and 49 males, which is not the usual ratio for a bisexual form in this group of Cynipidæ. Because of the early appearance of the gall on an evanescent part of the plant it is probable that this species has an alternate, agamic generation. The galls of this species resemble those of *Neuroterus pallidus* Bassett of the eastern United States, but in that species the clusters are borne at the ends of the aments instead of sessile on the young twig, distorting the whole ament.

Andricus spectabilis, new species

Plate XXIV, Figures 11 and 12

Female.—Head and thorax black; densely hairy; abdomen rufous; areolet very large, cubitus not continuous; average length 4.5 mm. Head: Dark piceous to black, mandibles rufous; about as broad as thorax, broadened behind eyes; very finely coriaceous, punctate, and hairy, dense with long hairs on the face, naked just

lateral to the eyes. Antennæ rufous brown to piceous, first segment darker, and darker apically; hairy; 14-jointed (or incompletely 15–jointed). THORAX: Black, piceous to black on the sides; very finely coriaceous, closely punctate and densely hairy with long hairs; parapsidal grooves distinct, punctate, slightly convergent at the scutellum, slightly divergent at the pronotum; median groove distinct and smooth for a short distance from the scutellum, obsolete forward; anterior parallel lines raised, smooth, extending about half-way to the scutellum; lateral lines somewhat smooth, extending from the scutellum about half the mesonotal length; scutellum black, longer than wide, deeply rugose, slightly depressed on the median line, with two large, shining, smooth or slightly rugose, laterally-spreading foveæ at the base separated by a fine ridge; mesopleuræ piceous or black, finely coriaceous and smooth, almost naked of hairs. ABDOMEN: Rufous to piceous, brightest at the very base and apically especially ventrally; practically smooth, the posterior segments, the ventral spine and valves with long hairs; only a few, scattering, long hairs at the base of the second segment laterally; abdomen longer than wide, the second segment covering about two-thirds the total area, and rounded ventrally, the hypopygium projecting slightly posteriorly. LEGS; Yellow-brown to rufous, the coxæ and sometimes trochanters black; hairy, hairs densest and longest on the tarsi and on the hind tibiæ; claws prominently toothed. WINGS: Hyaline, tinged with yellowish, covered with fine, brown hairs, edges ciliate; veins brown, heavy, cross-veins heaviest; longer than whole length of body, extending half beyond abdomen; areolet large, sometimes spectacularly so, extending sometimes one-third the way to the cubitus; cubitus not reaching basalis, the tip curved distinctly downward toward a point well below the mid-point of the basalis; radial cell apparently closed, but whether by the extension of the subcosta or by another thickening of the margin is not entirely evident; first abscissa of the radius arcuate-angulate, heavily but limitedly infuscated, without much of a projecting point. LENGTH: 3.7–4.7 mm.

GALLS (Pl. XXIV, Figs. 11, 12).—Elongate stem swellings. Polythalamous. Large, elongate, oval to spindle-shaped, averaging 2.5 cm. wide by 5.0 cm. long; large specimens of scarcely greater diameter will reach 11.0 cm. in length; covered with bark of natural color. Internally hard and woody, only the peripheral tissue being less compact than the normal stem wood; larval cells toward the center of the gall, oval, 3. by 5. mm., tissue almost not at all distinct from rest of wood; exit holes upon aging show a distinct, smoother area on the bark. On smaller stems of *Quercus chrysolepis.*

RANGE.—California: San Jacinto Mountains, San Bernardino, Upland, Pasadena, Placerville, Auburn.

TYPES.—Seventy-six females and 19 galls, labelled Pasadena, California; February 7, 1920; Kinsey collector. Holotype female, paratype females, and galls in The American Museum of Natural History; paratype females and galls at Leland Stanford University, the U. S. National Museum, and in the author's collection.

The galls of this species have been mistaken for those of *Andricus suttoni* (Bassett) which occurs on *Quercus agrifolia;* and it is likely that all the records of *suttoni* occurring on *Quercus chrysolepis* apply actually to *spectabilis.* Though the galls of the two cynipids closely resemble each other, the insects are not similar, exhibiting what will be interpreted as generic differences when *Andricus* is subdivided. In several respects, such as the median depression of the scutellum, this species shows rel

tions to *Andricus pomiformis* (Bassett). Adults emerged from galls at Placerville, California on March 30; but it is likely that there is an earlier emergence date for more southern material. The gall is prominent and very abundant wherever I have seen *Quercus chrysolepis*.

Bassettia ligni, new species

Plate XXIV, Figure 1

Female.—Almost wholly black; the thorax transversely rugulose, lateral lines distinct; edges of wings not ciliate; length, 1.7 mm. Head: Slightly wider than thorax, bulging behind eyes; black, rufous brown at mouth; coriaceous to shagreened. Antennæ almost black, rufous brown basally. Thorax: Elongate; entirely black; prominently but shallowly puncto-rugose, or transversely rugulose, naked of hairs; parapsidal grooves fine but distinct to the pronotum where they are gradually curved apart, gradually curving together at the scutellum; median groove very fine and short, a fine, median, shallowly rugose depression extending anteriorly; anterior parallel grooves fine, extending posteriorly not much more than a third the length of the mesothorax; lateral lines smoother areas or shallow grooves, distinct, short, not reaching the posterior edge of the mesonotum; scutellum longer than wide, the surface the same as that of the remainder of the thorax, the two, oval, small, shallow foveæ slightly rugose, distinctly separated by a rather fine ridge; mesopleuræ smooth and shining, in places shagreened or coriaceous, especially centrally and anteriorly. Abdomen: Almost black, piceous ventro-posteriorly; entirely smooth, naked except for a few hairs at the base, laterally, and the hairs on the ventral spine and valves; not quite as broad as long, not produced dorsally, the second segment covering about half the total area, only slightly produced dorsally, but with the ventral margin curved; edges of other segments more vertical; ventral valves at about a 60° angle. Legs: Brown-piceous, darkest on the coxæ, lightest at the joints and on the tarsi; finely pubescent; tarsal claws simple. Wings: Clear, finely set with hairs, margins *not* ciliate; veins light brown, rather fine, cross-veins and subcosta heavier; areolet moderate in size; cubitus reaching basalis; radial cell open; second abscissa of radius somewhat curved, first abscissa arcuate, hardly suggesting an angle. Length: 1.7 mm.

Galls (Pl. XXIV, Fig. 1).—Cells within the wood of small twigs, usually not distorting the stem, or producing hardly noticeable swellings. Each cell is elongate-oval, about 1.0 by 2.5 mm., with a shell-like lining, distinct from but hardly separable from the wood; the cells lie wholly within the wood, which is not particularly modified; often a hundred or more are closely crowded in dense clusters. Exit holes, cleanly circular, about 0.5 mm. in diameter, disclose the infestation. On twigs of *Quercus Douglasii*.

Range.—California: Galt.

Types.—Five females (all imperfect) and 12 pieces of infested twigs. Holotype female, paratype female, and galls in the collections of The American Museum of Natural History; paratype females and galls with the author; galls at Leland Stanford University and the U. S. National Museum. Labelled Galt, California; March 29, 1920; Kinsey collector.

This very distinct genus regularly produces galls of about this simple type, and search for exit holes in otherwise undeformed twigs will probably produce, as I have already experienced, more species of the group. Species have been obtained heretofore only from Georgia, Florida, Missouri, Colorado, Arizona, and New Mexico, but not from the Pacific Coast. Insects were still emerging at Galt on March 29, but apparently most of them had emerged previously. The galls were mostly in the two-year-old wood, only rarely in the wood of the previous summer; but whether it takes the species more than one year to develop I cannot say because it was not carefully determined at the time which galls were producing the emerging insects.

Neuroterus decipiens, new species

Plate XXIV, Figure 9

Female.—Piceous black, pale yellow toward the mouth; antennæ brown, yellowish basally; areolet small; abdomen produced dorsally; length averaging 1.7 mm. Head: As wide or slightly wider than the thorax, not widened behind the eyes; piceous black, darkest on the front, lighter on the face, pale yellowish-white toward the mouth, on the mouth-parts, and under the head for the most part; surface almost smooth, microscopically rougher in places, naked, very sparsely hairy on the lower part of the face. Antennæ brownish, first two, three, or four segments pale yellow; hairy, least so basally; 13-jointed, second joint globose, third longest and most slender, last almost twice the length of the preceding. Thorax: Piceous black, lightest on the sides; mesothorax entirely smooth and shining, naked, entirely without the usual grooves and lines; scutellum entirely smooth, shining, naked, an arcuate furrow at the base; pronotum and mesopleuræ almost smooth, shining, and naked, only very microscopically coriaceous. Abdomen: Piceous black, lightest on the hypopygium, smooth, shining, naked; irregularly triangulate, distinctly produced dorsally. Legs: Mostly light yellowish, yellow to piceous on the coxæ; smooth, hairy; tarsal claws simple. Wings: Clear, minutely hairy; hind margin long-ciliate, front margin hardly ciliate; veins rather rich-brown, cubitus the lightest; areolet moderately small; cubitus reaches the basalis; radial cell long, narrow, open, the second abscissa of the radius about straight; first abscissa somewhat angulate without a projection. Length: 1.5–1.8 mm.

Male.—Differs from the female as follows: almost wholly golden yellow, eyes about black, abdomen brownish yellow; antennæ brownish apically, 14-jointed, third segment curved and incised; abdomen long, narrow-triangulate, long-pedicellate; areolet varying from somewhat larger to closed; radial area open but more nearly closed than in the female; length, 1.7–2.0 mm.

Galls (Pl. XXIV, Fig. 9).—Clusters of egg-like cells in the leaf-blade. Each cell monothalamous, oval, about 1.7 mm. long by 1.0 mm. wide, thin-walled, entirely hollow, equally protruding from either surface of the leaf; leaf-green, drying brownish yellow. In dense, compacted clusters containing many scores of cells; on young leaves of *Quercus Douglasii*.

Range.—California: Stanford University (I. C. McCracken, Coll.), Three Rivers, and Redding.

Types.—Thirty-nine females, 11 males, 40 clusters of galls. Holotype female, paratype females, males, and galls in The American Museum of Natural History; paratype adults and galls in Leland Stanford University, the U. S. National Museum, and the author's collection. Labelled Redding, California; April 2, 1920; Kinsey collector.

This species is very abundant early in the spring; the galls are very succulent and the insects mature quickly after the unfolding of the leaves. There must be, therefore, another generation in the year, probably agamic. Insects were emerging at Three Rivers on March 22, but some hundred miles farther north, at Redding, adults did not emerge until some time after collection of the galls on April 2. Of 93 adults of my collection, only 14 are males, not the usual ratio for bisexual generations of this genus. Material of this species is in several collections labelled *Neuroterus pacificus* Beutenmüller, but this is obviously not that species.

Neuroterus engelmanni, new species

Plate XXIV, Figure 4

Female.—Entirely piceous black; antennæ brown, straw-yellow basally; wing-veins light brown but cubitus and discoideus almost colorless; length averaging under 1.0 mm. Head: Somewhat wider than thorax, broadened behind eyes; piceous black, mandibles rufous brown; microscopically reticulate, the front smooth and naked, hairy about the mouth. Antennæ brown, straw-yellow basally, the third segment very much the longest and most slender. Thorax: Piceous black, microscopically reticulate, devoid of thoracic grooves, naked of hairs, not shrivelling as much as in many species of this genus; scutellum elongate cushion-shaped, an arcuate, smoother furrow at the base. Abdomen: Entirely piceous black, naked of hairs; finely but not long pedicellate; angulate-oval in shape, not as triangulate and shrivelled as in many species of the genus. Legs: Piceous yellow, darkest basally, brown to straw-brown toward the tips of tarsi, but the tips dark; finely pubescent. Wings: Clear, long-ciliate on margins; veins brown, cubitus and discoideus fine and light in color; areolet of moderate size; radial cell moderately long, narrow, open; cubitus reaching the basalis (though hardly discernible there) nearly at the point of union of the basalis with the discoideus; first abscissa of the radius about arcuate. Length: 0.7–1.2 mm.

Galls (Pl. XXIV, Fig. 4).—Pustulate swellings embedded in the leaf-tissue; monothalamous, but often several galls confluent; about circular, averaging 1.2 mm. in diameter. The surface of the leaf not modified, the under surface somewhat distended, the upper surface less so but very evidently swollen; thin-walled, hollow. On leaves of *Quercus Engelmannii.*

Range.—California: Alpine, Fallbrook.

Types.—Eleven females, and a great many galls. Holotype female, paratype females, and galls in the collections of The American Museum of Natural History; paratype females and galls at Leland Stanford University, and with the author;

galls in the U. S. National Museum. All the adults are imperfect. Labelled Fallbrook, California; February 26, 1920; Kinsey collector.

The galls were very abundant on the few trees on which they were found. On February 24 and 26 they contained only larvæ. Of the two or three thousand insects bred from one of the lots of galls, only eleven gall-makers were recovered, the other insects being parasites. The galls closely resemble *Neuroterus niger* Gillette which occurs on *Quercus macrocarpæ*, *N. perminimus* Bassett on *Q. alba*, *N. papillosus* Beutenmüller on *Q. bicolor*, and several other species which I shall describe from other species of oaks. The insects of these species show evident relationships morphologically, and it is of considerable significance to find the galls (an expression of the physiology of the insect!) similarly related. These species are certainly distinct, but it may be desirable at some time to label them varieties. Such "host varieties" are biologically important because of the material they may offer for experimental work on the possible effect of environment (the host) on the insect.

Neuroterus varians, new species

Plate XXIV, Figures 17 and 18

Female.—Entirely black, including the legs and the antennæ for the most part; abdomen extending ventrally as far as or farther than dorsally; areolet of a moderate size to closed; length varies, 1.0–1.8 mm. Head: As wide or wider than the thorax, protruding slightly back of the eyes; black, light rufous brown around the mouth and on the mouth-parts; only microscopically coriaceous; practically naked of hairs. Antennæ piceous black, the second and third segments in part lighter piceous; hardly hairy; with 13 segments, third most slender and longest but not considerably longer than fourth, last segment not much longer than the preceding. Thorax: Entirely black; mesothorax smooth, shining, naked of hairs, entirely without the usual grooves and lines; scutellum smooth, shining, naked, with a smooth, arcuate furrow at the base; pronotum smooth, very finely punctate and hairy at the sides, not very evidently so; mesopleuræ practically smooth, shining and naked. Abdomen: Black, piceous ventro-apically; smooth, naked; usually protruding as far or farther ventrally than dorsally, as high or higher than long. Legs: Black (piceous in small individuals), light piceous yellow at the joints and on the tarsi, tips of tarsi dark; shining, smooth except for minute punctures, minutely hairy; tarsal claws simple. Wings: Long, clear, set with very fine hairs, long-ciliate on the hind margins, hardly ciliate on the anterior margins; veins light brown; areolet of moderate size (small or closed in small individuals); cubitus continuous to the basalis; radial cell open, not as long and narrow as usual in this genus; first abscissa of the radius sharply angulate, very slightly infuscate where it leaves the subcosta. Length: 1.5–1.8 mm. (individuals vary, down to 1.0 mm.).

Galls (Pl. XXIV, Figs. 17, 18).—Short, blunt, irregular stem swellings. Polythalamous. Distorted lateral stems, 5.–12. mm. in diameter, 6.–35. mm. long, very rough, covered with bark of natural color; very irregular in shape, involving distorted buds, petioles, or leaves. Internally the larval cells are closely compacted, located mostly

toward the periphery; cells oval, averaging 1.5 by 0.8 mm., but varying in size; cells with a distinct, shell-like lining which is not, however, separable. On *Quercus lobata*.

RANGE.—California: Byron.

TYPES.—Over 200 females and 49 clusters of galls. Holotype female, paratype females, and galls in the collections of The American Museum of Natural History; paratype females and galls in Leland Stanford University, the U. S. National Museum, and the author's collection. Labelled Byron, California; March 19, 1920; Kinsey collector.

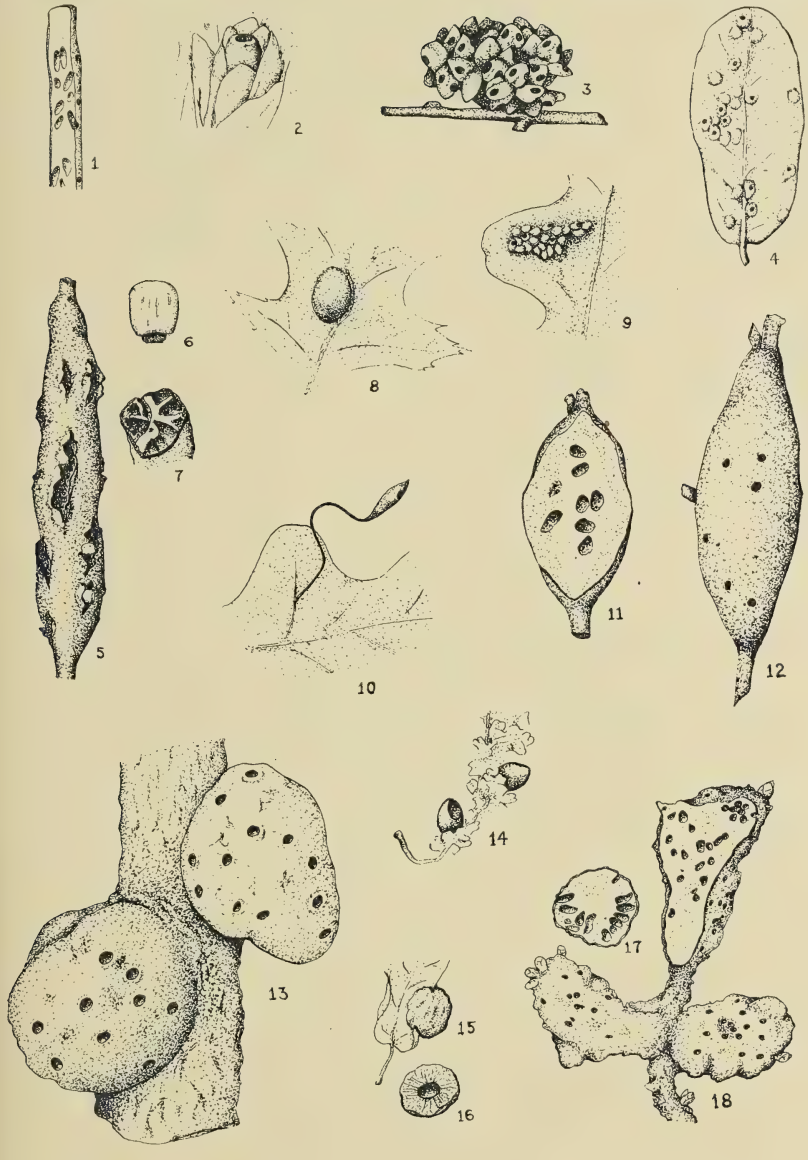
This species shows a considerable variation in the size of the adults, the color of the legs, and the size of the areolet. All of the material, which gave almost eight hundred adults, was collected from a single tree; the smaller individuals appear structurally and almost entirely in regard to color indentical with the largest individuals, and what differences do exist show all the intermediate stages in still other individuals. So I have no doubt that these variations are all within a single species, but to avoid any chance of confusion I have sorted out a series of the largest individuals as paratypes.

Adults emerged March 21, a couple of days after collecting the galls.

Plate XXIV

Fig. 1. *Bassettia ligni*, new species; natural size.
Fig. 2. *Andricus attractans*, new species.
Fig. 3. *Andricus serricornis*, new species.
Fig. 4. *Neuroterus engelmanni*, new species; natural size.
Figs. 5 and 7. *Andricus perdens*, new species; reduced.
Fig. 6. *Andricus perdens*, new species; larval cell.
Fig. 8. *Andricus perfoveatus*, new species.
Fig. 9. *Neuroterus decipiens*, new species; natural size.
Fig. 10. *Andricus pedicellatus*, new species.
Figs. 11 and 12. *Andricus spectabilis*, new species; reduced.
Fig. 13. *Andricus humicola*, new species; reduced.
Fig. 14. *Andricus gigas*, new species.
Figs. 15 and 16. *Andricus atrimentus*, new species.
Figs. 17 and 18. *Neuroterus varians*, new species.

All figures enlarged except as noted.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Article IV.—BIRD REMAINS FROM THE CAVES OF PORTO RICO

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INTRODUCTION

As an outcome of a Natural History Survey of the Island of Porto Rico undertaken by the New York Academy of Sciences in coöperation with the Insular Government of Porto Rico, Mr. H. E. Anthony of The American Museum of Natural History, in June and July 1916, made extensive collections of the mammals of the island, more especially from deposits of bones found in caverns. The existing native mammalian fauna (belonging to the order Chiroptera) was enriched by remarkable species of ground sloths, insectivores, and rodents, now extinct but represented bountifully by bones preserved in cave deposits. In this rich material, now well known through publications by Mr. Anthony[1] on the subject, were encountered remains of birds embracing a considerable amount of material. I am indebted to Mr. Anthony and to the authorities of the American Museum for the privilege of studying this collection of bird bones, of especial interest to me since from December 1911 to September 1912 I was engaged in field studies of the living avifauna of Porto Rico. These bird bones came into my hands in 1919, but prolonged absence in the field in other work delayed the completion of a final report on the collection.

The species of birds included in the Porto Rican Cave fauna as covered in this collection number 42, of which 6 have been described as new, 5 from bones alone and one, a whippoorwill, discovered by its skeletal remains, named from a skin formerly considered as belonging to another species. An additional species (*Nesotrochis debooyi*) I characterized a few years ago from material secured in kitchen middens on the islands of St. Thomas and St. Croix. In all, seven extinct species of birds are covered in this report.

[1]Ann. New York Acad. Sci., XXVII, Aug. 9, 1916, pp. 193–203; Bull. Amer. Mus. Nat. Hist., XXXV, Nov. 16, 1916, pp. 725–728; idem, XXXVII, Jan. 29, 1917, pp. 183–189; idem, Sept. 7, 1917, pp. 565–568; Mem. Amer. Mus. Nat. Hist., New Series, II, part 2, Oct. 12, 1918, pp. 333–435. See also J. A. Allen in Ann. New York Acad. Sci., XXVII, Jan. 25, 1916, pp. 17–22.

OCCURRENCE OF BONE DEPOSITS

From Mr. Anthony's account[1] the following quotation will indicate the conditions under which the deposits containing bones of birds were found.

> The fossil remains were encountered at depths of a few inches from the top down to as deep as nine feet. Often but little scraping was necessary to uncover bones although in this connection it is necessary to state that the natives of the island are in the habit of digging out the bat guano from the caves and frequently take the earth from the floor of the caves as fertilizer. Thus the height of the earth in any cave may not always be considered with certainty as the maximum depth of the deposit. However the height of the original deposit is generally betrayed by a discolored ring around the walls of the cave. . . . As a general rule the specimens were found in dry caves in the limestone in the mountainous part of the island. Caves up on the sides of small hills yielded the most bones and the size of the cave was immaterial. . . . The Cueva Catedral near Morovis . . . occupies the top of a small hill and the ceiling of the cave has fallen through letting in considerable light. This cave has two large entrances and is a large open chamber filled to a depth of several feet with earth and many fallen fragments of limestone. At one side there is a deep deposit of fine powdery soil, almost pure bat guano in spots, sloping rather steeply down from the back wall of the cave. . . . Throughout a stratum of several inches to a foot or more in thickness this deposit was literally packed with small bones of mammals, birds, reptiles and amphibians. In some spots the bones were interlaced almost in hundreds and a quart of earth required some minutes to pick over. In the crevices between the larger blocks of limestone and in the irregularities in the cave floor were especially rich pockets of those bones.

A small number of bones of birds were secured from what is known as the Toraño Cave near Utuado (covered by collecting numbers 2, 3, and 4). Near the Hacienda Jobo, also in the vicinity of Utuado, birds were collected in one large cavern and two smaller caves near by (collecting numbers 5, 5.2, 5.3). Specimens of birds from this region, however, were relatively few. The bulk of the collection was taken in Cueva Catedral (collecting number 8), with considerable material from Cueva Clara (No. 7) and a less amount from Cueva San Miguel (No. 6), all located near the town of Morovís. Both of the regions where collections were made lie on the northern, more humid, side of the mountain range that passes east and west through the island. Utuado and the surrounding region are in the drainage of the Rio Grande de Arecibo and occupy a well-forested tract of somewhat broken hills. Morovís, on a branch of the Rio Ciales, lies in somewhat similar country but in a region that is rougher and more broken. Study of the present avifauna and of historical accounts written after the discovery of Porto Rico indicate

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[1] 'Indigenous Land Mammals of Porto Rico,' Mem. Amer. Mus. Nat. Hist., New series, II, part 2, Oct. 12, 1918, pp. 338–339.

that most of the northern slopes of the island were heavily forested, with openings confined to small glades save where open savannas marked marshy localities on the coastal plain. In the northwest near Quebradillas there is a more arid open section, as the northeast trades cross the island in that region without being deprived of their moisture through elevation along mountain slopes. The cavern deposits, however, come from the humid, forested region and represent the ancient avifauna of that section.

FORMATION AND AGE

An examination of the species represented in the cavern collections shows that most of them were of small size; in fact, bones of birds larger than a thrush or blackbird are comparatively few in number. It is evident that the great mass of these small bones have come from pellets or casts of owls. The formation of owl pellets is a process well known to naturalists. The birds forage for prey, which, in case of warm blooded vertebrates, is swallowed in lumps with bones and a large part of the feathers or fur that form the bodily covering. When all nutritive matter has been absorbed the remaining indigestible portions are cast up or regurgitated in the form of pellets containing the bones encased in masses of feathers and fur. These collect in considerable amounts about favorite roosts of owls. During years past, in studying the food of owls, I have examined several thousand such pellets for the purpose of identifying the species of vertebrates represented by bones therein. Considerable familiarity with the degree of preservation of such material enables me to say without hesitation that the small-bone deposits in the Porto Rican caves have come largely, if not entirely, from such a source.

At the present time there is found in Porto Rico the naked-footed owl, *Gymnasio nudipes nudipes* (Daudin), a species that preys to some extent on birds and that is partial to caverns. As numerous remains of this owl were found with the other bones, there can be no question but that it was instrumental in bringing in a considerable proportion of the small-vertebrate débris. The discovery of remains of the Porto Rican barn owl, *Tyto cavatica* Wetmore, adds another to aid in this work, as barn owls are noted as frequenters of caverns. The short-eared owl, *Asio portoricensis* Ridgway, though reported by natives to dwell in caves, must have been confused with the barn owl, as short-eared owls universally are inhabitants of grassy savannas. Bones of birds too large to have been carried in by owls, found in small numbers, may have reached resting places with the other material as the prey of man or through accident.

The fact that these bones have been deposited in casts from owls renders the question of their probable age a difficult one. With all tendinous attachments dissolved away by digestive action, absence of tendon ends or fatty matter in the bone is of no value as a criterion of antiquity. Bones that survive the vigor of strigine digestive juices are durable, as I have observed on many occasions, and, unless covered with limelike excrement and so subject to the corrosive action of the acid present in the renal excreta, show no tendency to rapid decay. The cave deposits under discussion yield bones varying from a few that are still white and obviously modern to others stained dark brown, perhaps from a leach from overlying deposits of bat guano. The majority are dull buff in color and frequently are very brittle. On first consideration I was inclined to place the age of the bulk of this material at from one hundred to one thousand years. On reconsideration I believe that some of the remains, especially when found under breccia, may range back for two thousand years or even for a considerably longer period. Under the accounts of some of the species of birds at present extinct I have included notes that indicate their existence within historic times. At Cayey and again at Mameyes I heard of an animal, described as light in color and without a tail, that had disappeared during the boyhood of the grandfathers of the old men telling the tales. In the light of later discoveries this may indicate that *Isolobodon portoricensis* Allen, an agoutilike animal, existed still at the close of the eighteenth century.

THE CAVERN AVIFAUNAS

Cueva Catedral

From the Cathedral Cave remains of 35 species of birds were identified, all of small or moderate size, as shown in the following tabulation.

List of Species from Cueva Catedral

Cerchneis sparveria
Accipiter striatus
Gallinago anthonyi
Oreopeleia montana
Oreopeleia larva
Chæmepelia passerina
Zenaida zenaida
Patagiœnas leucocephala
Patagiœnas squamosa
Chlorœnas inornata
Saurothera vieilloti
Melanerpes portoricensis
Gymnasio nudipes
Setochalcis noctithera
Tyrannus dominicensis
Tolmarchus taylori
Myiarchus antillarum
Blacicus blancoi
Petrochelidon fulva
Margarops fuscatus
Mimus polyglottos
Mimocichla ardosiacea
Vireosylva calidris
Dendroica adelaidæ
Dendroica coronata
Mniotilta varia

Cœreba portoricensis
Agelaius xanthomus
Icterus portoricensis
Holoquiscalus brachypterus
Nesospingus speculiferus
Spindalis portoricensis
Loxigilla portoricensis
Tiaris olivacea

Pigeons were common and were represented by seven species, including the extinct *Oreopeleia larva*. With these were considerable numbers of bones of the Porto Rican woodpecker (*Melanerpes portoricensis*), of four flycatchers, a swallow, a thrasher, a mockingbird, and a thrush, with three blackbirds, two tanagers (one of these, *Nesospingus speculiferus*, in great abundance), two finches, a vireo, a honey creeper, and three wood warblers. Two of the latter, the black and white warbler (*Mniotilta varia*) and myrtle warbler (*Dendroica coronata*) are migrant (at least in modern times) from the North American Continent. The largest birds in this collection are large pigeons, and the sparrow hawk and Antillean sharp-shinned hawk.

Cueva Clara

The fauna from Cueva Clara, while less varied, still numbered 27 species of birds, including several not encountered in Cathedral Cave, as is shown by the following enumeration.

List of Species from Cueva Clara

Dendrocygna arborea
Gallus gallus
Nesotrochis debooyi
Porzana flaviventris
Gallinago anthonyi
Oreopeleia montana
Oreopeleia larva
Chæmepelia portoricensis
Zenaida zenaida
Patagiœnas leucocephala
Patagiœnas squamosa
Chlorœnas inornata
Saurothera vieilloti
Melanerpes portoricensis
Gymnasio nudipes
Setochalcis noctithera
Tyrannus dominicensis
Tolmarchus taylori
Margarops fuscatus
Mimus polyglottos
Mimocichla ardosiacea
Agelaius xanthomus
Icterus portoricensis
Nesospingus speculiferus
Spindalis portoricensis
Coturniculus savannarum

Parts of a tree-duck and remains of the large extinct rail (*Nesotrochis*) may indicate that this cavern was the resort at times of Indians, while a few bones of the domestic fowl suggest more modern visitors. Seven species of pigeons are noted. From bones of the yellow-shouldered blackbird (*Agelaius xanthomus*) and grasshopper sparrow (*Coturniculus savannarum*) we may conjecture that open savannas were found near at hand. Other species offer little worthy of comment save the presence of the yellow-bellied rail, the snipe (*Gallinago anthonyi*), and remains of the naked-footed owl, probably the marauder reponsible for

the other small-bird remains. The whippoorwill (*Setochalcis noctithera*) is represented in this cavern as in the Cathedral Cave.

Cueva San Miguel

The San Miguel Cave in this same region has a smaller fauna, as it included only five species.

List of Species from Cueva San Miguel

Nesotrochis debooyi	*Mimocichla ardosiacea*
Chlorœnas inornata	*Corvus pumilis*
Gymnasio nudipes	

These belong to diverse groups and include as the most interesting species the small crow (*Corvus pumilis*) that is today extinct. The large extinct rail, the plain pigeon, the naked-footed owl, and the Porto Rican thrush conclude the tale of species for this locality.

Of the 42 species of birds identified from the entire collection 40 come from these three caves near Morovís so that these give a fair idea of the avifauna at a time before the region had been markedly changed by the invasion of the Caucasian race.

Cueva Toraño

The Toraño Cave, with a representation of eight forms of birds, offers the largest array of avian species of the caverns investigated in the Utuado district.

List of Species from Cueva Toraño

Dendrocygna arborea	*Oreopeleia larva*
Polyborus latebrosus	*Tyto cavatica*
Nesotrochis debooyi	*Gymnasio nudipes*
Oreopeleia montana	*Mimocichla ardosiacea*

Among these may be noted a tree-duck and a few fragments of a Caracara (*Polyborus latebrosus*). The extinct rail and two pigeons occur here also, together with the extinct Porto Rican barn owl, the naked-footed owl, and the Porto Rican thrush. The birds found are of moderate to large size and are poorly represented.

Caves on the Hacienda Jobo

The three caverns investigated on the Hacienda Jobo yielded in all only three species.

List of Species from Hacienda Jobo

Cave No. 1	Cave No. 2
Chlorœnas inornata	*Chlorœnas inornata*

Cave No. 3

Cerchneis sparveria
Nesotrochis debooyi

In two instances the plain pigeon was the only species discovered; in the remaining cave were fragments of the sparrow hawk and of the large land rail.

The total fauna from the Utuado region comprises only 11 species, a poor showing in comparison with the findings from the three caverns near Morovís. Indications are that conditions in the Utuado region were less favorable for the preservation of small fragile bones.

The entire cave avifauna adds six species, all extinct, to the known list of Porto Rican birds and is responsible for the discovery of a seventh form, the whippoorwill.

ANNOTATED LIST OF SPECIES

ANATIDÆ

1. **Dendrocygna arborea** (Linnæus)

The West Indian tree-duck is represented in the present collection by the proximal end of a right ulna taken from the cave on the property of Don Gervacio Toraño near Utuado, and by fragments of a skull found in Cueva Clara near Morovís. The latter shows some sign of having been subjected to fire. In it the attachment of the sub-orbital bar is evident at the lower end of the post-orbital process, though the bar itself, diagnostic of the skull in the genus *Dendrocygna*, has been lost. No peculiarity is evident in these specimens. The species occurs at the present time in small numbers in Porto Rico.

FALCONIDÆ

2. **Cerchneis sparveria** (Linnæus)

In Cueva Catedral the sparrow hawk was represented by right and left humeri, and a right metacarpus from a somewhat immature bird, while from cave No. 2 at the Hacienda Jobo near Utuado comes an ulna. Modern sparrow hawks from Porto Rico, common residents on the island, belong to the subspecies *loquacula*, described by Mr. J. H. Riley.[1]

BUTEONIDÆ

3. **Polyborus latebrosus** Wetmore

The type of the Porto Rican caracara is a fragmentary right metacarpus (Fig. 1), discovered together with the proximal end of a right ulna in a cave on the property of Don Gervacio Toraño near Utuado. The original description[2] of this species was as follows.

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[1]Smiths. Misc. Coll., Quart. Iss., XLVII, part 2, Nov. 8, 1904, p. 284.
[2]Proc. Biol. Soc. Washington, XXXIII, Dec. 30, 1920, pp. 77–78.

Fig. 1. *Polyborus latebrosus.* Proximal end of right metacarpus (type), anterior view, natural size. From Cueva Toraño.

Characters.—Metacarpus similar to that of *Polyborus cheriway* (Jacquin)[1] but slightly larger; first metacarpal proportionately higher, more massive especially at the base (when viewed from behind), and with less inward flexure at the tip (Fig. 2); proximal end of third metacarpal with surface slightly excavated to form a concavity; excavation anterior to pisiform process more distinctly delimited; inner margin of condyle raised in a distinct crest.

Description.—Type, Cat. No. 4921, Dept. Vert. Pal., American Museum Nat. Hist., proximal end of right metacarpus, from cave on the property of Don Gervacio Toraño, near Utuado, Porto Rico, collected July 2, 1916, by H. E. Anthony.

Metacarpus with first metacarpal strong and massive especially at the base; head produced and slightly enlarged at extremity, showing a very slight inward flexure; articular surface for pollex broadened, supported by a basal buttress; a slight notch posteriorly at base marking junction with second metacarpal; two minute foramina on either side at base; a shallow anterior carpal fossa on posterior face; outline of carpal articulation viewed from inner side forming part of an ellipse with axis vertical, the posterior margin forming one side of the ellipse; upper margin here produced in a distinct ridge; posterior carpal fossa slight; pisiform process low; internal ligamentous fossa deeply impressed; a distinct elongate fossa on inner surface anterior to pisiform process, sharply marked by inner extension of margin of third metacarpal as a distinct ridge; base of second metacarpal strong and heavy; lower surface of third metacarpal distinctly excavated so that it is concave.

Fig. 2. *Polyborus latebrosus.* Right metacarpus (type). View of face of proximal articulation, slightly larger than natural size. From Cueva Toraño.

Measurements.—(Of type). Extreme height (through crest of first metacarpal) 16 mm.; length of first metacarpal 9.2 mm.; diameter of base of first metacarpal (behind expansion for pollex) 2.5 mm.

Range.—Known only from cave on the property of Don Gervacio Toraño near Utuado, Porto Rico. (Extinct.)

The discovery of the extinct Porto Rican caracara marks a considerable extension of range for the genus *Polyborus* in the West Indies. Its nearest neighbor, the familiar *Polyborus cheriway*, is found now in Cuba and the Isle of Pines and on the south occurs in Trinidad and some of the small, arid islands off the coast of Venezuela. The fragments representing *P. latebrosus*, while small, are so distinctive that there has been no hesitation in assigning to them a specific name, though the portion of an ulna mentioned is of little value in comparison, as it indicates only that *latebrosus* was larger than *P. cheriway* (Jacquin) and smaller than *P. plancus* Miller.

[1]Compared with specimens of *P. cheriway* from Florida.

From *Polyborus plancus* Miller (represented by skeletons from Patagonia) the metacarpus of *latebrosus* differs in having the first metacarpal (when viewed from behind) more slender, especially at the base, the crest on the inner margin of the condyle stronger, the notch at the outer margin of the proximal condyle lower so that it is found at the line of ankylosis of the first and second metacarpals instead of above that point, and the lower surface of the third metacarpal more excavated at the base. In general, it may be said that *P. latebrosus* appears to stand in an intermediate position between *P. cheriway* and *P. plancus*, but that it is distinct from either. It may be noted that it shows no particular affinity with *P. lutosus* Ridgway from Guadeloupe Island off the coast of Lower California, a skeleton of which is available for comparison.

The skeletal material of *P. cheriway* used in the present studies comes from Florida. Skins of this species from Brazil and Venezuela that I have examined show that caracaras from that region are smaller and have weaker bills than those from North America, as has been pointed out by Outram Bangs and G. K. Noble.[1] These authors separate the larger North American bird from *Polyborus cheriway cheriway* (Jacquin) of northern South America as *Polyborus cheriway auduboni* Cassin. As the remains of *Polyborus latebrosus* from Porto Rico are larger even than those of *P. c. auduboni* from Florida (the type locality of Cassin's bird), there is no reason to suppose that the differences ascribed to *latebrosus* are those characterizing caracaras of the typical subspecies *cheriway* from South America.

After careful study of skeletons of *Polyborus cheriway*, *plancus*, and *lutosus*, and *Ibycter ater*, I have no hesitation in placing *latebrosus* in the genus *Polyborus*, although we may perhaps expect to find remains of carrion hawks of the genus *Ibycter* in the West Indies. The differences existing in the metacarpus in these two groups as shown in the material at hand may be summarized as follows.

a. Outline of inner margin of condyle distinctly oval; tubercle on outer margin longer, less elevated; a distinctly excavated pit above pisiform process... *Ibycter.*

aa. Outline of inner margin of condyle more angular, more rounded than oval; tubercle on inner margin shorter, more elevated; pit above pisiform process absent or only slightly impressed..... *Polyborus.*

It is to be hoped that further remains of *Polyborus latebrosus* may come to light. These should be encountered in the drier, more open areas of the southern side of Porto Rico, or in the slightly arid stretches near Quebradillas, regions well suited to the needs of these carrion hawks,

[1] Auk, XXXV, 1918, p. 443.

which would hardly have found a congenial environment in the heavy rain forests that in former years covered much of the northern part of the island.

4. **Accipiter striatus** Vieillot

Remains of the Antillean sharp-shinned hawk were found in Cueva Catedral, where a broken right humerus and a left tibio-tarsus, nearly complete, were collected. These bones may be attributed to the well-marked subspecies *Accipiter striatus venator* Wetmore,[1] the form of this small, bird-eating hawk found on Porto Rico. In identification comparison has been made with skeletons of *A. s. striatus* from Santo Domingo. The bones from Cueva Catedral are small in size and in all probability represent a male individual. As in some of the Santo Domingan specimens examined, the humerus from Porto Rico has the lower margin of the crista inferior produced until it forms an abrupt right angle with the margin of the shaft. In general outline, appearance, and size, the humerus is closely similar to that of *Cerchneis sparveria* (family Falconidæ) but may be told at a glance by the position of the nutrient foramen. In *Accipiter* this opening lies immediately below the head of the bone opposite the lower part of the crista superior. In *Cerchneis* the foramen is on the shaft of the bone below its center.

The Porto Rican sharp-shinned hawk has been known until now only from the type specimen, secured near Maricao, and from two other individuals observed but not collected in this same locality. These bones from near Morovís are, therefore, important in giving an additional locality from which this bird has been recorded.

PHASIANIDÆ

5. **Gallus gallus** (Linnæus)

A right coracoid, obviously fresh in appearance, from Cueva Clara near Morovís comes from a medium-sized domestic fowl. At first glance this bone suggests the guinea fowl, which is said to have been introduced into Porto Rico through the agency of Genoese slave-ships. The bone in question, however, has a large pneumatic foramen near the lower end (on the inner dorsal surface) as in the genus *Gallus*, while the coracoid in the Numididæ (judging from specimens of *Numida meleagris* and *Agelastes meleagrides*) is non-pneumatic and has no such foramen.

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[1]Proc. Biol. Soc. Washington, XXVII, July 10, 1914, p. 119.

Rallidæ

6. **Porzana flaviventris** (Boddaert)

A right femur was secured in Cueva Clara near Morovís. This bone, slender and delicate in form, is typically ralline in configuration and proportions, and may be recognized at a glance as from a member of that group. It is similar to the femur in a yellow-bellied rail collected in Haiti by Dr. P. Bartsch (U. S. Nat. Mus. No. 225936). The femur from Cueva Clara differs only in slightly greater length, as it measures 26 mm., while the modern specimen from Haiti is only 23.5 mm. long.

The proportionate length of tarsus and femur in small rails is of some interest. In a specimen of *Creciscus cinereiceps* Ridgway (U. S. Nat. Mus. No. 19163) the tarsus measures 31.5 mm. and the femur 32 mm. In a skeleton (coll. A. W., No. 285) of *Porzana carolina* (Linnæus) the tarsus measures 33 mm., the femur 36 mm. Tarsi in four skins of *P. flaviventris* from Cuba, Jamaica, and Porto Rico vary from 22.5 mm. to 24.5 mm. The relative proportions of the two bones in these species is seen to be more or less constant, the femur being slightly longer than the tarso-metatarsus.

In modern times the yellow-bellied rail has been recorded in Porto Rico only from the coastal plain, at the Laguna de Guanica, along the Rio Arecibo, and near Bayamon. The femur from near Morovís represents apparently the highest point from which the species has been known.

7. **Nesotrochis debooyi** Wetmore

This large ralline species described originally[1] from bones secured in kitchen middens on islands of St. Thomas and St. Croix was found in four localities as follows.

Cueva Clara, one entire left femur, distal end of another from the right side; lower end of a right tibio-tarsus; and part of a sacrum.

Cueva San Miguel, one entire left tibio-tarsus and part of another; and a left humerus.

Cave "5.3," one left tibio-tarsus.

Toraño Cave, July 1, 1916, a left humerus and the lower end of a metatarsus.

These specimens mark a considerable extension of range for this bird, and also afford a further insight into its osteology as it was described originally from femora and tibio-tarsi alone. The material at hand from different islands, so far as may be seen, apparently all belongs to one species as, although considerable variation in size is apparent, this seems

[1]Proc. U. S. Nat. Mus., LIV, 1918, p. 516.

individual (perhaps connected with sex) and may not be correlated at present with any one of the three geographic areas from which the bird is now known.

The femora from Porto Rico are much more robust than the femur from St. Thomas selected as type in the original description of the species. The specimen that is entire has the following measurements (measurements of type given in parentheses for comparison): Length, 81 mm. (76.5); transverse diameter through center of head, 19.5 mm. (17); transverse diameter through medullary foramen, 8 mm. (7.5); intercondylar diameter, 18.5 mm. (16.6[1]). The configuration of the bone (Figs. 3, 4, and 5) is the same as in the type save that in the Porto Rican specimens the processes are more heavily sculptured.

Fig. 3 Fig. 4 Fig. 5 Fig. 6 Fig. 7

Nesotrochis debooyi

Fig. 3. Posterior view of left femur, one-half natural size. From Cueva Clara.
Fig. 4. Anterior view of left femur, one-half natural size. From Cueva Clara.
Fig. 5. External view of left femur, one-half natural size. From Cueva Clara.
Fig. 6. Internal view of left tibio-tarsus, slightly less than one-half natural size. From Cueva San Miguel.
Fig. 7. Anterior view of left tibio-tarsus, slightly less than one-half natural size. From Cueva San Miguel.

Measurements of the two entire tibio-tarsi from Porto Rico are as follows: Length, 114 mm., 120.5 mm.; breadth through lower end of peroneal ridge, 9.5 mm., 9 mm.; greatest breadth through condyles, 13.7 mm., 12 mm.[2]; length of articular face of peroneal ridge, 20.5 mm., 20 mm.[2]

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[1]Not exact owing to imperfection in specimen.
[2]Not exact because of wear.

At first glance the tibio-tarsi (Figs. 6 and 7) from Porto Rico seem stronger than those from St. Thomas, the type locality of *debooyi*. A broken bone from St. Thomas, however, indicates a specimen as heavy as those from Porto Rico, while the series from St. Croix all average almost as large as the Porto Rican bones. At present, therefore, I am inclined to consider these remains as indicative only of individual variation in a single species.

A left tibio-tarsus from cave 5.3 shows evidence of scraping near the upper end of the shaft, apparently through human agency. The flattened space that has been ground off is cut so deeply that it has formed an irregular oblong opening into the inner canal.

The bit of a tarso-metatarsus, fragmentary and badly worn though it is, offers more of interest as it is a portion of the skeleton hitherto unknown. The distal third of the bone remains, with the two lateral trochleæ broken away, leaving only the trochlea for the third toe in place. The lower end of the tarsus was compressed and flattened, with a large foramen below the groove between second and third trochleæ. In form it resembles the tarso-metatarsus of *Aramides ypecaha* but is broader and has the base supporting the laterally placed fourth trochlea long, sloping more gradually into the shaft of the bone. The remaining trochlea is slightly stronger than in an adult female of *ypecaha*.

The fragment of a pelvis from Cueva Clara consists merely of the anterior half of the sacrum from which the ilia have been broken away. The bone agrees in form with that in *Aramides ypecaha* but is heavier, indicating that the pelvic region, in keeping with the strongly muscled legs of the bird, was larger and more strongly built. The fragment shows a part of the free anterior articular surface, and on the left side has a trace of the ilium still adherent to it. The lateral processes indicate five fused vertebræ, the last of which has been nearly broken away. The lower surface of the bone near its center is very slightly excavated as in *Aramides*. In *Gallirallus australis* the lower surface of this bone is distinctly ridged through the center so that the ventral excavation is double.

The humeri (Figs. 8 and 9) are among the most interesting finds in these deposits as they give further clue to the affinities of this strange species. The bone is slender, strongly curved, with the shaft more or less cylindrical and with little flattening. The caput humeri is set at a very oblique angle with the shaft, showing a slight articular surface remarkable for being broadened posteriorly and narrowed anteriorly, instead of the reverse as is usually the case. The tuberculum externum is slightly

produced. The incisura capitis is a broad groove with nearly perpendicular walls and a slightly hollowed floor, notable for its backward extension on the outer side due to the posterior expansion of the caput humeri. The notch in the humeral head at the anterior end of the sulcus is slight. The internal tuberculum, present only in one specimen, is strong, with the inferior crest reduced to a small tubercle. The depression marking the fossa subtrochanterica is very slight and is impressed mainly in the side of the internal tubercle, with no lateral or posterior continuation owing to the reduction of the inferior crest. There is no pneumatic foramen. The crista superior is slight and weak, more reduced than in *Gallirallus*. Its outer external margin is distinctly concave instead of convex, and the crest sinks into the shaft at once. The articular surface for the pectoral tendon is reduced to a small area barely larger than that marking the attachment for the supracoracoidal muscle. The latter, due to the restriction of the pectoral facet stands out prominently. The shaft of the bone below the head is triangular in cross-section to near the center, where it becomes rudely terete. Above the distal extremity it is compressed as is usual. The ridge for the attachment of the latissimus dorsi is well marked. The usual opening for the nutrient foramen on the inner side is indicated by an imperforate pit, located nearer the center of the shaft than is usual in rails. There is a small canal near the lower end of the subtrochanteric fossa. The ectepicondylar process is stronger than ordinary in rails, and the shaft of the bone is less flattened at this point than usual. The radial trochlea, though well developed, has the sulcus for the anconeus lateralis deep, forming a furrow with raised outer margin extending over the inner and dorsal surfaces to the end of the process. The ulnar trochlea is comparatively slight, with the entepicondylar process strong and heavy in proportion. The popliteal depression is broad and flattened, but is only slightly impressed. The entire humerus, while similar in type to that of *Aramides*, has the small muscle attachments and weakened configuration found in *Gallirallus*.

Fig. 8 Fig. 9

Nesotrochis debooyi

Fig. 8. Anterior view of left humerus, one-half natural size. From Cueva San Miguel.

Fig. 9. Posterior view of left humerus, one-half natural size. From Cueva San Miguel.

In the original description of *Nesotrochis debooyi*, based on leg bones alone, comparison was made mainly with *Aramides cayanea*. Note was made of the resemblance of the new species to the weka rail, *Gallirallus australis*, a resemblance due mainly to the strong robust development of

the lower limb in *Nesotrochis*. In the present review I have available a complete skeleton of *Aramides ypecaha* (female) that I collected at Lazcano in eastern Uruguay on February 7, 1921. It is readily apparent that *Nesotrochis*, though distinct from the wood-rails, is allied to them. When compared with *A. ypecaha*, the largest species in the genus, bones of the lower limb are similar in general form but are heavier and have all processes much more strongly developed. After careful study I consider *Nesotrochis* as a highly specialized offshoot from the primitive stock that has produced *Aramides* and closely allied (but not ancestral) to that group of species. If we consider *Aramides* as of South American origin, as seems logical at present, then *Nesotrochis* may be considered as another of the interesting remnants of the ancient West Indian fauna that has been derived from South America. Study of the wing bones indicates that the species was flightless, a defect that may have led to its extermination, as the bird, judging from the occurrence of bones in kitchen middens, was used as food by the aborigines. In Porto Rico I heard frequently of the hunting in former times of the *Carao* or limpkin (*Aramus vociferus*) by natives, who, during the early morning hours, followed this bird on foot, with aid of dogs, through dew drenched vegetation until, its feathers thoroughly soaked so that it could not fly, the quarry was tired out and captured alive. One may wonder whether part, if not all, of these hunting tales may not have related to the taking of the flightless wood-rail *Nesotrochis*, rather than to the strong-winged limpkin, a species that takes to wing at the slightest alarm.

Scolopacidæ

8. **Gallinago anthonyi** Wetmore

This snipe was noted first in remains from Cueva Catedral, where a right humerus (type), a left humerus, a left metacarpal, a right coracoid, two right and one left tarso-metatarsi, and the distal portions of one right and one left tibio-tarsus were found. In the remains from Cueva Clara the species was represented by a left humerus. This material is sufficient to give a fair idea of the limb bones of this bird.

The original description of *Gallinago anthonyi*[1] was as follows.

Characters.—Humerus (Figs. 10, type, and 11) similar to that of *Gallinago delicata* (Ord), but distinctly larger and longer; ectepicondylar process shorter; crista superior relatively smaller.

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[1]Proc. Biol. Soc. Washington, XXXIII, December 30, 1920, p. 78.

DESCRIPTION.—Type, Cat. No. 4922, Dept. Vert. Pal., American Museum Nat. Hist., right humerus, from Cueva Catedral, near Morovís, Porto Rico, collected in July, 1916, by H. E. Anthony.

Humerus with head comparatively broad, crista superior relatively low and slightly developed, projecting outward nearly at right angles to shaft, with the projecting margin strongly rounded in outline; fossa subtrochanterica rather shallow; no pneumatic foramen; nutrient foramen situated well above middle of bone 17 mm. from extremity of caput humeri; shaft comparatively strong, much flattened and broadened toward distal end; base of ectepicondylar process low, summit distant 5.6 mm. from extremity of radial condyle (tip of process broken away); depression for brachialis inferior broad and well marked; ulnar condyle elongate.

Fig. 10 Fig. 11

Gallinago anthonyi

Fig. 10. Posterior view of right humerus (type), about natural size. From Cueva Catedral.

Fig. 11. Anterior view of left humerus, about natural size. From Cueva Clara.

MEASUREMENTS.—(Of type). Total length, 43.4 mm.; greatest breadth of head 10.7 mm.; lateral diameter of shaft at center 3.4 mm.; intercondylar breadth, 7 mm.

RANGE.—Known from Cueva Catedral and Cueva Clara, near Morovís, Porto Rico. (Extinct.)

When compared with *Gallinago delicata* (Ord), which may be taken as representative of the ordinary snipes of the genus, the humerus in *anthonyi* is longer and larger, the ectepicondylar process is proportionately shorter, the distal end of the bone relatively broader, and the crista superior relatively smaller. The same distinctions hold for *G. paraguayæ* and *braziliensis*. The humerus from Cueva Clara (Fig. 11) is distinctly larger than the type (Fig. 10) and has the following dimensions: Total length, 44.3 mm.; greatest breadth of head, 11.5 mm.; lateral diameter at center of shaft, 3.6 mm.; intercondylar breadth, 8.2 mm. The condyles of the type are somewhat worn, so that the intercondylar breadth was originally more than the dimension given for that specimen. The second humerus from Cueva Catedral is so near in size to the one from Cueva Clara that there is no need to detail its measurements.

Fig. 12. *Gallinago anthonyi*. Anterior view of left metacarpus, natural size. From Cueva Catedral.

The coracoid assigned to *anthonyi* is broad and strong, with prominent lines indicated for muscle attachment. It is similar to the coracoid of the other snipes available (the species enumerated in the paragraph above) but is longer, stronger, and heavier. There is a deep excavation on the external posterior face of the acrocoracoid, and the glenoid facet is elongate and strong. A strong, hooklike projection arising from the

acrocoracoid evidently met the furculum. The procoracoid is produced upward. The lateral process or wing has been broken away. The bone indicates a bird of strong robust body. The total length of the bone (acrocoracoid to center of articular facet) is 23 mm.

The metacarpal (Fig. 12) is stronger and heavier than in *G. delicata* and the other species available, though the general configuration is similar. The second and third metacarpals are much heavier throughout, particularly the latter, which is much broader when viewed from below. The external groove is relatively wider and more heavily defined. The specimen measures as follows: Total length, 27.6 mm.; height through first metacarpal, 7.3 mm.; height through center, 5.1 mm.

The two tibio-tarsi are worn to such an extent that they offer little that is worthy of comment save to note that they average greater in size than *G. delicata* and the other species with which comparison is made. Both bones have the heads missing but in one a part of the peroneal ridge is present. The shafts are slender, yet strong. The condylar ends articulate perfectly with the heads of the tarso-metatarsi that are next described. These tibio-tarsi offer no measurements of value because of their worn and broken condition.

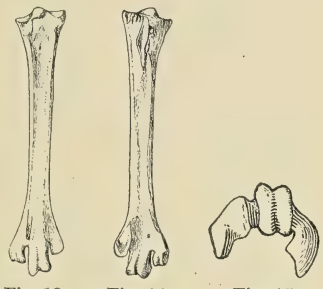

Fig. 13 Fig. 14 Fig. 15

Gallinago anthonyi

Fig. 13. Anterior view of right tarso-metatarsus, natural size. From Cueva Catedral.

Fig. 14. Posterior view of right tarso-metatarsus, natural size. From Cueva Catedral.

Fig. 15. Distal outline of trochleæ of right tarso-metatarsus, twice natural size. From Cueva Catedral.

The three tarso-metatarsi of *Gallinago anthonyi* are of a type to be expected from study of the bones that have been mentioned previously. In conformation (Figs. 13, 14, and 15) they suggest the tarso-metatarsus of other snipe, more especially *Gallinago braziliensis* but, while bones of the two species are similar in length, those of *anthonyi* are heavier and more robust. The inner trochlea is broader and heavier in proportion to those supporting the middle and outer toes, and the talon has a deeper excavation on the inner side. The shaft is strong and broad throughout; otherwise the bone offers no peculiarities. Measurements of the two nearly perfect bones are as follows: Total length, 34.8, 35.6 mm.; smallest transverse diameter of shaft, 2.8, 2.8 mm.; breadth of head, 5.9, 6.4 mm.; breadth across trochleæ, 6.6, 7 mm.; (depth through talon indeterminate). It will be noted that one specimen is slightly larger than the other, a difference due perhaps to sex.

The presence of remains of a snipe distinctly larger than the Wilson's snipe (that occurs in Porto Rico in fair numbers during winter) is one of the most interesting finds in the present collection. Though a part of the bones representing it are old and stained, others are light and rather fresh in appearance and do not appear to have great age. The relationships of *Gallinago anthonyi* to some of the larger South American snipes is at present uncertain through lack of comparative material. It is possible that the present species may have some affinity with the peculiar group of species of comparatively restricted range termed the "semi-woodcocks" by Seebohm, so-called because they seem to combine the characters of snipes and woodcocks. Of these the giant snipe (*Gallinago undulata*), a species of truly enormous size as it is almost as large as a ruffed grouse, is said to range (in two subspecies) in swamps from Guiana south through Brazil into northern Argentina. Two other species (*G. jamesoni* and *G. imperialis*) are found in the Paramo of the northern Andes, while a third (*G. stricklandi*) is known in Tierra del Fuego and Chile. These are sometimes included in the genus *Homoptilura* distinct from true *Gallinago*. The low elevation of the ectepicondylar process of the humerus in *G. anthonyi*, with other characters of form that distinguish it from other species of *Gallinago* proper at hand, are an indication of difference that may possibly ally *anthonyi* with some of these South American types of obviously archaic origin, a matter, however, that may be settled only when further material illustrating the peculiar South American species has been examined.

Columbidæ

9. **Oreopeleia montana** (Linnæus)

The ruddy quail-dove was represented from Cueva Catedral by five femora and seven humeri, from Cueva Clara by a left femur, and from Cueva Toraño by the distal end of a right tarso-metatarsus and a left coracoid. (Specimens from the last-named locality were collected July 1.) The humeri from Cueva Catedral are all from juvenile birds in which the ends of the bones were still soft, so that the usual bony processes are mainly gone and the bone appears soft and spongy. In fact, most of the bones listed seem to come from immature individuals. This quail-dove today is still fairly common in Porto Rico in coffee plantations and other forested tracts, though sadly decimated in numbers by the mongoose and by hunting on the part of natives.

10. **Oreopeleia larva** Wetmore

The type (Fig. 16) selected in describing the extinct *Oreopeleia larva*[1] was a left tarso-metatarsus from Cueva Catedral. Following is a complete list of the bones identified as belonging to this quail-dove.

Cueva Catedral: 3 right and 6 left tarso-metatarsi, 4 right and 2 left tibio-tarsi, 3 right and 1 left femora, 1 right metacarpal, 1 left coracoid, the fused vertebræ from a pelvis, and a synsacrum.

Cueva Clara: 1 right and 3 left tarso-metarsi, 2 left tibio-tarsi, a right coracoid, and a right metacarpal.

Cueva Toraño: 2 right tarso-metarsi, and 2 right tibio-tarsi.

Fig. 16. *Oreopeleia larva.* Anterior view of left tarso-metatarsus (type), slightly less than natural size. From Cueva Clara.

Though some of these bones are fragmentary, it will be seen that the new species was based on abundant material.

The original description was as follows.

Characters.—Metatarsus similar to that of *Oreopeleia leucometopius* Chapman from Santo Domingo, but distinctly longer.

Description.—Type, Cat. No. 4923, Dept. Vert. Pal., American Museum Nat. Hist., left metatarsus, from La Cueva Clara, near Morovís, Porto Rico, collected in July, 1916, by H. E. Anthony.

External glenoid facet (Fig. 17) concave, with a high external border near center, rudely elliptical in outline; internal glenoid facet also with high external border, nearly circular in form; intercondylar prominence strong, in form resembling a truncated cone, with the apical surface sloping anteriorly; anterior semilunar groove very slight; anterior surface of bone below head excavated in a long groove that lies mainly on the inner side; both external and internal superior foramina present, the first penetrating through to opposite side; tubercle for insertion of tibialis anticus tendon slight; outer anterior margin ridged to a point below the anterior groove where the entire bone shows a broad flattened surface; inner crest of talon very slightly indicated; outer crest strong and heavy with the posterior semi-lunar groove well developed; outer head of talon with one median perforation and two external grooves, that are not closed; posteriorly the talon is produced in a thin sharp ridge that descends rapidly to merge with the body of the bone at the anterior third of its length; junction of talon with shaft marked externally by a low ridge that curves anteriorly; internal margin of bone produced anteriorly as a thin plate that slopes in a curve to join the talon, and that has a sharp outer margin; shaft greatly flattened distally; a raised line extending from the crest of the talon down the center of the shaft behind to curve outward finally to the base of the outer trochlea; another less definite line passes to the inner trochlea; inner trochlea (Fig. 18) produced outward and backward as an

Fig. 17. *Oreopeleia larva.* Proximal view of head of left tarso-metatarsus (type), slightly more than twice natural size. From Cueva Clara.

[1]Proc. Biol. Soc. Washington, XXXIII, Dec. 30, 1920, p. 79.

Fig. 18. *Oreopeleia arva.* Distal outline of trochleæ of left tarso-metatarsus (type), twice natural size. From Cueva Clara.

angular projection with a flattened lateral point; middle trochlea projecting well beyond other two, rounded in outline, flattened laterally, with excavated sides and a deep median channel; outer trochlea strong and heavy, produced outwardly and posteriorly and excavated behind, where it is also heavily grooved; a large external inferior foramen and a faintly indicated internal one.

Measurements.—(Of type). Total length 39.5 mm., smallest transverse diameter of shaft 2.5 m., breadth of head 6.7 mm., breadth across trochlea 7 mm., depth through talon 6.5 mm.

Range.—Known from Cueva Clara and Cueva Catedral near Morovís, and a cave on the property of Don Gervacio Toraño near Utuado. (Extinct.)

Oreopeleia larva was a quail-dove of moderate body frame (slightly larger than *O. montana*, but smaller in frame than *Geotrygon versicolor*), characterized by its long slender tarsus, a character that in combination with others allies it to *Oreopeleia caniceps* of Cuba and *O. leucometopius* Chapman (recently described[1] from specimens collected by R. H. Beck on Mt. Tina and at Tubano and Las Canitas, Province of Azua, Santo Domingo). This species is placed without question in the genus *Oreopeleia*. *Geotrygon versicolor* of Jamaica has the extremities of the metatarsus larger than in *larva*, the transverse diameter across the tibial articulation is broader, and the bone at this point is heavier. *O. larva* has the whole metatarsus seemingly more slender than in the Jamaican bird. The tibio-tarsus of *O. larva* is much stronger and heavier than that of *O. montana*, surprisingly so in fact, so that for a time I was uncertain of the identity of these bones. Two complete specimens measure 62 mm. and 62.5 mm. respectively. Though robust in form when compared with *O. montana*, these bones are slenderer and more elongate than in the tree pigeons.

The resemblance of *O. larva* to *Oreopeleia martinica* from the central Lesser Antilles is closer. No skeleton of *martinica* is at hand at present, but study of the tarsus in skins furnishes sufficient points of distinctness between the two species. The tarso-metatarsus in *martinica* (measured from the outer margin of the proximal head to the end of the middle trochlea) is usually shorter than in *larva* but in one specimen (U. S. Nat. Mus. No. 75176, male) it equals 38 mm. However, in *O. martinica* the toes are long and strong and the trochleæ supporting them correspondingly heavy, a character that serves to differentiate the two species without trouble. When compared with *Oreopeleia leucometopius*, also represented only by skins, the resemblance is marked. The metatarsal

[1]Bull. Amer. Mus. Nat. Hist., XXXVII, May 14, 1917, p. 327.

bone in *larva* has the same slender form and small trochlea found in *leucometopius*, a species characterized by rather short toes. The total length of the tarso-metatarsus in four complete specimens of *larva* varies from 38 mm. to 38.5 mm. Dr. Chapman gives the length of the tarsus in five males of *leucometopius* as 34 mm. and in five females as 32 mm. In a male of the same species in the U. S. National Museum, collected by Dr. W. L. Abbott, the tarsus measures 34 mm., and in a female from the same source 35.5 mm. The tarsus in *Oreopeleia caniceps* is slightly longer, as it ranges in males (six specimens) from 32 mm. to 37 mm. with an average length of 34 mm.[1]

The two modern quail-doves known from Porto Rico, *Oreopeleia montana* and *O. chrysia*, may be dismissed in the present connection with the statement that they are smaller birds of a different type. *Oreopeleia mystacea*, of which one specimen is known from the island of Culebra, east of Porto Rico, was also a species with decidedly shorter tarsus.

The skeletal elements associated with the tarsi taken as representing *O. larva* show little save that they indicate a bird of larger, slightly heavier frame than *O. montana* but less robust than *Geotrygon versicolor*.

Quail-doves as a whole are ground inhabiting species of forest habitat. *Oreopeleia larva* would seem from its structure to have been a form of similar habit that flourished in the primitive forests of Porto Rico and perhaps became extinct only with the destruction of tree growth during the later history of the settlement of the island.

11. **Chæmepelia passerina** (Linnæus)

In the remains from Cueva Catedral are right and left femora and tibio-tarsi, a right humerus, and a broken right metacarpal of the ground dove, perhaps all from one individual. Two left humeri come from Cueva Clara. These bones exhibit no notable peculiarity. The modern ground dove from Porto Rico, one of the commoner birds of the island, is placed in the subspecies *C. p. trochila* (Bonaparte), a form that ranges from Porto Rico through the Lesser Antilles north of St. Vincent.

12. **Zenaida zenaida** (Bonaparte)

The Zenaida dove was commonly represented in both Cueva Catedral and Cueva Clara, while additional bones come from Cueva Toraño, and a single humerus from San Miguel cave. The humerus in this bird is large and strong in proportion to its size, so much so that for a time I

[1]Ridgway, 1916, 'Birds of North and Middle America,' VII, p. 471.

was uncertain as to its identity through lack of comparative material. It is characterized by elevation of the ectepicondylar tubercle as in *Zenaidura* and *Ectopistes*. The modern Zenaida dove, abundant in the island of Porto Rico, where it has the habits, notes, and appearance of a mourning dove is distinguished as *Z. z. lucida* Noble.

13. **Chlorœnas inornata** (Vigors)

The plain pigeon was well represented in the material studied, as bones more or less complete were found in Cuevas Catedral, Clara, San Miguel, and in the two caves explored on the Hacienda Jobo near Utuado. The remains consists of limb bones and parts of sterna and are to be distinguished from those of related pigeons by their large size and robust form.

In comparison of humeri of *Chlorœnas inornata* with those of *Patagiœnas squamosa* and *P. leucocephala* the following differences are noted.

a. Olecranal fossa shallow, inner wall merging with adjacent entepicondylar process in a gentle slope (forming a basin-like depression).... *Chlorœnas inornata.*

aa. Olecranal fossa deeper, inner wall abrupt, forming a distinct pit at base of entepicondylar process..... *Patagiœnas squamosa. Patagiœnas leucocephala.*

It may be noted that in the band-tailed pigeon, *Chlorœnas fasciata* the olecranal pit is developed as in *Patagiœnas*. *C. fasciata*, like *P. squamosa* and *P. leucocephala*, is a bird that performs extended flights either to seek new food supplies or in migration. *C. inornata*, on the other hand, is more sedentary and apparently is resident in the Greater Antillean islands where it occurs, as several subspecies have been described. (It is probable that Cuban and Santo Domingan birds now listed as one may prove separable when sufficient material is available.) The form of the inner margin of the olecranal fossa would seem, therefore, to be correlated with exercise of flight.

The modern plain pigeon from Porto Rico is distinguished as *Chlorœnas inornata exsul* Ridgway. The species as a whole ranges through Cuba, Isle of Pines, Jamaica, Santo Domingo, and Porto Rico, but is far from common in the latter island at the present day.

14. **Patagiœnas leucocephala** (Linnæus)

A right femur and part of a left one from Cueva Clara, slightly smaller than similar bones in *P. squamosa*, are taken as representing this species. The white-crowned pigeon is today one of the more common of the larger pigeons in Porto Rico. It is encountered in numbers in the hills and in forested regions near the coast, where it is said to be migrant in part to and from other Antillean islands.

15. **Patagiœnas squamosa** (Bonnaterre)

Represented by a broken femur and parts of two right metacarpals from Cueva Catedral, and a tarso-metatarsus and femur from Cueva Clara. These limb bones are similar to those of *P. leucocephala* but are slightly larger.

The humerus in pigeons of the families Treronidæ, Columbidæ and Peristeridæ is a characteristic bone to be confused with that of no other group of birds save the parrots. The peculiar, sharply triangular crista superior projecting from the stout heavy shaft is diagnostic. In addition, the extensor metacarpi radialis longus inserts on the humerus on a distinct tubercle that may be called the ectepicondylar tubercle, separated by a distinct space from the expanded radial condyle. Its elevation varies. In *Zenaidura* and *Ectopistes* it is higher than in others. In the Gouridæ the attachment of the tendon is low and does not form a tubercle on the shaft, as it is on a true ectepicondylar process continuous with the condylar region of the humerus.

The humerus in parrots is closely similar to that in pigeons. In general, the crista superior in such groups as *Ara* and *Amazona* is more angular, and the ectepicondylar tubercle broader, with its area of tendinous attachment extending around on the upper surface of the bone, not restricted to the outer margin as in pigeons. In addition, in parrots the pit for the brachialis inferior is much longer.

The scaled pigeon remains today fairly common in forested districts.

Cuculidæ

16. **Saurothera vieilloti** Bonaparte

The lizard cuckoo, a species that may be considered tolerably common at present, was represented in Cueva Catedral by one right and four left tarso-metatarsi, a left femur, left humerus, and left metacarpal, while in the remains from Cueva Clara were a left tarso-metatarsus and a left tibio-tarsus. A broken tarso-metatarsus was found in Cueva Toraño. It is worthy of note that the cuckoo remains from these caves are those of the forest inhabiting *Saurothera* rather than of the ani (*Crotophaga*), a bird frequenting more open country. It is believed that anis have been extending their range through the West Indian Islands within modern times so that it is barely possible that *Crotophaga* was not represented in the Porto Rican avifauna at the time of these deposits.

The tibio-tarsus of *Saurothera* is characterized by a strong anterior curvature with small development of the proximal crests. It differs from that of *Crotophaga* in the longer peroneal ridge that extends farther down on the shaft.

Picidæ

17. **Melanerpes portoricensis** (Daudin)

A left humerus and two right tibio-tarsi come from Cueva Clara, while in Cueva Catedral was found an assortment of bones from at least eighteen or twenty individuals. The majority of these are the heavier limb-bones. Much individual variation in size is evident in studying this series, and one might think that two species were represented if it were not for the manner in which the bones intergrade in series from large to small. Tibio-tarsi vary in length from 30.5 mm. to 33.5 mm., and femora from 20.5 mm. to 23.5 mm. A small number of bones are stained very dark brown and appear much older than others. These older bones frequently are larger than more modern specimens. There is in particular one tibio-tarsus of maximum size that, if complete, would measure not less than 34.5 mm. in length. The Porto Rican woodpecker has remained abundant in the coffee plantations of the hills since the destruction of the primeval forests.

Bubonidæ

18. **Gymnasio nudipes** (Daudin)

This small owl was abundantly represented in Cueva Clara and Cueva Catedral, while humeri were identified in the material from Cueva San Miguel and Toraño. The bones at hand exhibit great variation in size, as is usual among small owls; in that respect these bones of *Gymnasio* equal the series of skeletons of *Otus asio* in the collection of the National Museum. A metatarsus from Cueva Catedral represents a fledgling individual, as it has the spongy structure common to bones of young birds. Among other metatarsi are two that appear quite recent, as they have the hardened posterior tendons still held in place by a calcareous cement. Humeri from Cueva Clara vary from 41.5 mm. to 47 mm. in length, which will give an idea of the variation indicated in these specimens.

This owl is encountered in fair numbers in Porto Rican forests today and also frequents caverns to some extent. As the majority of the bird bones examined show evidence of having come from owl pellets, *Gymnasio* was probably responsible for many of the remains, especially of the large numbers of such small birds as the tanagers, woodpeckers, thrushes, and thrashers. Responsibility, however, was divided with the barn owl and the share to be attributed to these separate species is problematical.

TYTONIDÆ

19. **Tyto cavatica** Wetmore

The Porto Rican barn owl is represented by the proximal three-quarters of a left metatarsus (Fig. 19, the type) with the inner crest of the talon missing, about one-third of a right metatarsus, the upper half of a right tibio-tarsus, and the lower end of another. Apparently at least two individuals are represented. This material comes from individuals that were fully grown but that were less than one year old. All of the specimens were found in the Toraño cave.

Fig. 19

Fig. 20

Tyto cavatica

Fig. 19. Anterior view of proximal portion of left tarso-metatarsus (type), natural size. From Cueva Toraño.

Fig. 20. Internal face of proximal end of right tarso-metatarsus, natural size. From Cueva Toraño.

The original description of the species was as follows.[1]

CHARACTERS.—Metatarsus (Figs. 19 and 20) similar to that of *Tyto glaucops* (Kaup) from Santo Domingo, but with internal head of talon larger and much longer, the lower margin more elongated; tubercle for insertion of tibialis anticus tendon heavier.

DESCRIPTION.—Type, Cat. No. 4924, Dept. Vert. Pal., American Museum Nat. Hist., proximal three-fourths of a left metatarsus from cave on the property of Don Gervacio Toraño, near Utuado, Porto Rico, collected July 2, 1916, by H. E. Anthony.

Metatarsus with base supporting inner head of talon long, sloping gradually below, and truncate in front (crest of talon missing in type); posterior semi-lunar groove deep and narrow; anterior semi-lunar groove shallow; inner glenoid facet moderately impressed and concave; outer glenoid facet smooth without marked depression; entire posterior face of bone deeply grooved; ridge bearing inner head of talon swung over slightly toward center from inner margin, with a marked depression on inner face of the crest; outer side of metatarsus flattened, with angular margins, becoming narrower in a curving line toward head of bone, and expanding again slightly to support outer glenoid surface; anterior surface of bone excavated proximally in an elongate, roughly triangular groove; tubercle for insertion of tibialis anticus long and strong, extending well toward head of bone; lower end of bone with a distinct forward flexure; no osseous loop for extensor digitorum communis tendon.

MEASUREMENTS.—(Of type). Lateral diameter of head across articular surface 10 mm.; lateral diameter of shaft near center 4 mm.; length of base of inner head of talon 8.7 mm.

RANGE.—Known only from cave on property of Don Gervacio Toraño, near Utuado, Porto Rico. (Extinct.)

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[1]Proc. Biol. Soc. Washington, XXXIII, Dec. 30, 1920, p. 80.

The inner crest of the talon is broken and lost in the metatarsus selected as the type specimen. It is, however, complete in the second metatarsus, where its strong heavy form may be easily appreciated when compared with the weaker development characterizing *Tyto glaucops*. The long base and sloping angles of the inner crest of the talon in *Tyto cavatica*, save for smaller dimensions, resemble almost exactly the condition found in *Tyto perlata*, so that on first glance it might be supposed that *cavatica* was in reality merely a smaller insular form of *perlata*. In *perlata*, however, the inner crest of the talon is swung over until the head lies nearly above and parallel to the median line of the bone, with the external face of the talon on a marked slant from the perpendicular. In *glaucops* and *bargei* (here taken as representative of the smaller forms of barn owl) this ridge has the outer face much less oblique, as the line of the crest is less strongly appressed toward the median line. In this character and in its small size *cavatica* resembles the small West Indian barn owls and is to be ranked as a seperate species with them.

Fig. 21. *Tyto cavatica*. External view of distal end of right tibio-tarsus, natural size. From Cueva Toraño.

The tibio-tarsal remains exhibit a few characters of interest. The head of this bone in *glaucops* differs primarily from *perlata* in the greater size and extent of the laterally directed outer anterior crest. The bird from Porto Rico has this crest even more developed than in *glaucops*, with the upper external angle slightly produced. The lower end of the bone (Fig. 21) shows a broad attachment for the distal end of the tibia, as is usual, and in general is similar to that in other barn owls.

While travelling in Porto Rico in 1912 I made frequent inquiry of natives regarding *Asio portoricensis*, an owl that I did not find in life. Two stories were current regarding the "Mucaro real," the common name for the short-eared owl. One related that it was found in grassy places or damp marshes, while near Utuado it was said to inhabit small caves on abruptly sloping hills and to appear only at night. To this last I did not give great credence, as it was contrary to the established habit of short-eared owls in other regions. With the record of bones of the barn owl from this same region, the apparent discrepancy is cleared, as it is evident at once that the cave-haunting bird must have been *Tyto cavatica*. Barn owls are retiring in habit and secretive in choice of haunts, so that it is barely possible that the species still lingers in isolated caverns in that region. Though such possibility may be remote, it is worthy of consideration on the part of those who may chance to have opportunity to visit the locality.

The presence of the barn owl in caverns on this island may go far to explain the abundant remains of small birds and rodents found in such deposits as that excavated in Cueva Catedral. On examination of the bird bones from this cave, I was convinced that they were from regurgitated pellets, and the remains of the little bare-legged owl, common among the other fragments, seemed to indicate that it was the responsible agent. The discovery of *Tyto cavatica*, however, gives the whole affair a different aspect and leads one to wonder whether or not the small "mucaro" may not have fallen at times into the talons of his larger relative.

CAPRIMULGIDÆ

20. **Setochalcis noctithera** Wetmore[1]

Humeri of a whippoorwill representing an unknown insular species were among the first finds in the material from Cueva Catedral, and the bird was described from a study skin preserved in the Field Museum of Natural History, apparently the only existing complete specimen of this interesting species. In all, one left and two right humeri, with a left metacarpal belonging to *S. noctithera*, were found in Cueva Catedral, while two more humeri came from Cueva Clara. These two points are the only definite localities known for the occurrence of the species, as the type skin was marked simply Porto Rico.

Fig. 22. *Setochalcis noctithera*. Anterior view of right humerus, natural size. From Cueva Catedral.

The humerus in *S. noctithera* (Fig. 22) is similar to that in *Setochalcis vocifera vocifera* (Wilson) but is distinctly shorter, with fossa subtrochanterica less in extent, ridge of tuberculum medium weaker, foramen pneumaticum larger and more exposed, incisura capitis with sides more abrupt forming a more acute angle at the base, and tuberculum superior less elevated, shaft slightly more curved. The metacarpal is smaller than in *vocifera*. These differences are relative but are readily seen on close comparison.

The country people in Porto Rico told me on several occasions of a bird that in former times called loudly and continuously at night, that no one ever was able to see. When abroad after dark, the tale proceeded, it was well for the ungodly among men to guard his speech against profanity (certain vulgar words being especially taboo), as otherwise the strange bird overhearing him might take offense and descend to kill the offender. The night caller had not been heard for many years, however,

[1]Proc. Biol. Soc. Washington, XXXII, Dec. 31, 1919, p. 235.

so that freedom of speech, profane or otherwise, was open to all by night as well as by day. It is possible that this tale of direct punishment of the sinful may refer to the former occurrence of *Setochalcis noctithera*, as it may be supposed that the Porto Rican whippoorwill, like other related species, had a persistent call note given during the hours of darkness, though that it had any active part in oversight of human morals is hardly to be presumed. The species may still exist in small numbers, as a small goatsucker flushed in a tract of forest near Rio Piedras in December 1911 may have been the present bird. None were heard singing during a period of ten months spent in field work on the island so that, if still existent, the Porto Rican whippoorwill must be very rare.

TYRANNIDÆ

21. **Tyrannus dominicensis** (Gmelin)

The symphysis of a mandible and a right humerus from Cueva Catedral, and a left humerus from Cueva Clara were the only remains of the gray kingbird identified. The species has probably gained its present status as one of the abundant Porto Rican birds since the former forested areas have been destroyed, as it is a bird of open country.

22. **Tolmarchus taylori** (Sclater)

The Porto Rican petchary was present as a small series of bones from Cueva Catedral, with many other passerine remains. A left humerus was found in Cueva Clara. The tarso-metatarsus in large tyrants is characterized by the large size and inward extension of the inner trochlea, and its marked separation from the middle trochlea. In addition, the inner trochlea is extended distally beyond the level of the outer one. Tarso-metatarsi of the petchary from Cathedral cave measure from 22.5 mm. to 23.5 mm., a length that, with the greater breadth across the trochlea, serves to distinguish them from the shorter, less heavy tarso-metatarsi of *Tyrannus dominicensis*. Larger size in general serves to differentiate tarso-metatarsi, humeri, and tibio-tarsi of *Tolmarchus taylori* from those of *Tyrannus dominicensis*, as the structure in the two species is very similar. Tibio-tarsi may be distinguished from those of higher, oscinine passerines (Fringillidæ, Tangaridæ and Icteridæ) by their lack of the prominent inner ridge lying on the inner face of the shaft of the bone opposite to and in the same plane as the peroneal ridge. This same inner ridge is extensively developed in the Picidæ. The ulna of *Tolmarchus* is shorter than that of the gray kingbird.

With the clearing of forest areas the gray kingbird, a bird of the open, has become much more abundant than the *Tolmarchus* on Porto Rico, a condition that was reversed formerly if the abundance of remains of the two species among the small bird bones found in Cueva Catedral is any criterion.

23. **Myiarchus antillarum** (Bryant)

An entire upper mandible, complete save for the ossified nasal capsules, was found in Cueva Catedral. This is a common forest-inhabiting species.

24. **Blacicus blancoi** Cabanis

The distal half of a right tibio-tarsus, a tiny fragment from a small bird, comes from Cueva Catedral. This species is known only from the western half of Porto Rico and is here recorded at the most eastern point in its range on the north slope of the mountains. In 1912 I found it at Ciales only a few miles farther west; the present record is a slight extension in the known occurrence of the species.

HIRUNDINIDÆ

25. **Petrochelidon fulva** (Vieillot)

The cliff swallow is recorded on the basis of two humeri from Cueva Catedral. The species is a common inhabitant of the mouths of caverns during the breeding season and ranges in feeding over the forests and open fields.

MIMIDÆ

26. **Margarops fuscatus** (Vieillot)

The pearly-eyed thrasher, at present a rare species on the main island of Porto Rico, may formerly have been more abundant, as remains of eighteen or twenty individuals come from Cueva Catedral and other fragments from Cueva Clara. The species was among the three or four most frequently represented in the former locality. In Porto Rico today this thrasher is rare, though it is one of the most abundant birds on the nearby islands of Desecheo, Vieques, and Culebra.

27. **Mimus polyglottos** (Linnæus)

Eleven humeri, nine from the right side, and a few bones from the lower limb were found in Cueva Catedral and four other fragments in Cueva Clara. These are characterized by small size in comparison with mockingbirds from eastern United States. In the humerus of *Mimus*

polyglottos the shaft on the dorsal surface immediately behind the tuberculum superior is sharply angular. The pit of the brachialis inferior is narrow and restricted.

According to present usage, mockingbirds from Porto Rico are placed in the subspecies *Mimus p. orpheus* (Linnæus). The species is common at present.

Turdidæ

28. **Mimocichla ardosiacea** (Vieillot)

One of the most abundant species in the deposits in Cueva Catedral was the Porto Rican thrush. Forty right and twenty-six left humeri were secured from this one cave, together with a considerable number of other bones. Other remains come from Cuevas Clara, Toraño, and San Miguel, indicating that the bird was common and well distributed at the time these deposits were made. Bones of this species are in a number of cases equal in size to those of the robust pearly-eyed thrasher (*Margarops fuscatus*), and in some cases it is difficult to distinguish between the two species. The premaxilla in *Mimocichla* (represented by one specimen from Cathedral Cave) is more slender and has the line of the culmen strongly ridged, with the ridge extending back on the nasal process. In *Margarops* the premaxilla is heavier, with the posterior part (of the culmen) flattened. Distinction between the two genera in the humerus is very slight and at times doubtful owing to individual variation. Small differences are as follows: In *Mimocichla* the tip of the tuberculum medium is more extended, the concavity between it and the tuberculum inferior more curved. When viewed from the end the caput humeri has the highest point in the curve of its dorsal surface external, toward the crista superior. The channel between radial and ulnar trochleæ is narrower and deeper.

Tarso-metatarsi in specimens of *Mimocichla* from Cathedral Cave are of maximum length. Measurements of total length of entire specimens are 41.5, 42, 41.5, 42, 40, 41, 42.8 and 40.5 mm. These measurements exceed by from 1 to 1.5 mm. the usual tarsal measurement taken from study skins because of the proximal projection of the ankylosed centrale rising between the inner and outer articular facets on the proximal end of the bone. According to figures given by Mr. Ridgway,[1] the tarsus in this bird varies from 36 mm. to 40.5 mm., with an average of 39.5 mm. for males and 37.4 mm. for females.

[1] 'Birds of North and Middle America,' IV, 1907, p. 81.

Metacarpals of *Mimocichla* differ from those of *Margarops* in being slightly narrower and more slender. On the inner side at the distal end the groove or depression between the fused ends of *m.* 2 and *m.* 3 is smooth in *Mimocichla*, but in *Margarops* has a raised margin at its beginning so that the depression is set off as an elongate pit.

The Porto Rican thrush, recognized at present as the subspecies *Mimocichla a. portoricensis* (Bryant), is a common bird in country districts.

Corvidæ

29. **Corvus pumilis** Wetmore

While in Porto Rico I heard rumor in one or two regions of a form of crow, other than the ordinary *Cuervo* (*Corvus leucognaphalus*) of the island—a smaller, to me more or less mythical species, distinguished under the name of "solitario," said to have been found many years before in wooded areas on the hill slopes below Lares. The discovery in Cueva San Miguel near Morovís of the ulna upon which the present name is based corroborates these stories and gives two known species of the genus *Corvus* in Porto Rico.

Fig. 23. *Corvus pumilis.* Inner face of right ulna (type), natural size. From Cueva San Miguel.

Following is the original description of *Corvus pumilis*.[1]

Characters.—Ulna (Fig. 23) similar to that of *Corvus palmarum* Württemberg, but distinctly longer, olecranon relatively longer, heavier and broader at tip; external margin bounding carpal articulation more produced; and shaft compressed to form an angular margin on inner side directly above carpal articulation.

Description.—Type, Cat. No. 4925, Dept. Vert. Pal., American Museum Nat. Hist., right ulna, from Cueva San Miguel, near Morovís, Porto Rico, collected in July, 1916, by H. E. Anthony.

Ulna with olecranon produced and strong, tip broad and blunt on the end, where it is impressed by an indistinct shallow pit; internal glenoid surface broadly elliptical, placed obliquely to the axis of the bone and with a shallow raised margin; external glenoid surface produced as a thin flattened plate, with outer margin slightly rounded and postero-external edge produced to form a right angle; insertion of external portion of triceps marked by an angular ridge; a distinct external ridge with an acute margin on shaft immediately below head; shaft with a slight external convexity; nutrient foramen on inner surface, 25 millimeters from extremity of olecranon; papillæ for attachment of secondaries fairly prominent; external margin of carpal head produced, extending slightly beyond margin of shaft.

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[1]Proc. Biol. Soc. Washington, XXXIII, Dec. 30, 1920, p. 81.

Measurements.—(Of type). Total length 68 mm., diameter of shaft on external surface 4 mm.

Range.—Known only from Cueva San Miguel near Morovís, Porto Rico. (Extinct.)

The species is known at present only from the ulna that served as the type. *Corvus pumilis* was intermediate in size between *Corvus palmarum* of Santo Domingo and *C. leucognaphalus* (known from Santo Domingo, Porto Rico and St. Croix[1]). The ulna in three females of *C. leucognaphalus* taken in Porto Rico measures 75 mm., and in a fourth 76 mm. As males in *leucognaphalus* are distinctly larger than females, these represent minimum measurements for this species. The type of *pumilis* is only 68 mm. long, a size that places it well without the limit of variation for the modern crow known as a living bird from Porto Rico. In a skeleton of a male of *Corvus palmarum* the ulna is only 62 mm. long so that *pumilis* cannot be closely allied with that species, nor with either *C. minutus* of Cuba or the peculiar slaty *C. jamaicensis* of Jamaica. Apparently *C. pumilis* was about as large as the fish crow (*Corvus ossifragus*) of the United States, a species that differs decidedly from it in conformation of the ulna. *C. pumilis* has the ulna intermediate in a way between *leucognaphalus* and *minutus*. It agrees with *leucognaphalus* in the development of the strong, produced olecranon, and with *minutus* in the more angular lower margin of the external glenoid plate. From both it is readily distinguished by the greater compression of the inner margin of the shaft above the distal end.

It is hoped that additional bones of this interesting bird may come to light. With the discovery of *pumilis* two forms of crow, one large and one small, are known from Cuba, Santo Domingo, and Porto Rico, carrying the distribution of this combination well through the Greater Antilles. It remains to be seen whether an additional species may not be found from deposits in Jamaica and whether crows formerly may not have ranged part way through the Lesser Antilles. As noted above, *C. leucognaphalus* has been identified in kitchen midden deposits on St. Croix, and it is possible that in former times crows ranged even farther through the Antilles toward the South American Continent.

Vireonidæ

30. **Vireosylva calidris** (Linnæus)

Represented by three tibio-tarsi and two humeri from Cueva Catedral. Bones of this species are distinctly larger than those of *Vireo-*

[1]See Wetmore, 1918, 'Bones of Birds collected by Theodoor de Booy from Kitchen Midden Deposits in the Islands of St. Thomas and St. Croix,' Proc. U. S. Nat. Mus., LIV, pp. 521–522.

sylva olivacea, a species for which there is a very doubtful record for Porto Rico but which has at present no valid standing in the list of species known from the island. The three tibio-tarsi of *V. calidris* from Cueva Catedral measure 28 mm., 28.5 mm., and 28.5 mm. respectively, while in three specimens of *V. olivacea* the tibio-tarsus ranges from 26 mm. to 26.8 mm. The humeri from Cueva Catedral are distinctly larger than in *V. olivacea*. *V. calidris* is a common bird of the forests, that forsakes Porto Rico, presumably for more southern localities, during the winter season.

MNIOTILTIDÆ

31. **Dendroica adelaidæ** Baird

A left humerus of Adelaide's warbler, a resident species, was found in Cueva Catedral. This resident warbler today is locally common.

32. **Dendroica coronata** (Linnæus)

The myrtle warbler, a common winter visitant to Porto Rico, was represented by a left humerus from Cueva Catedral.

33. **Mniotilta varia** (Linnæus)

A tibio-tarsus of this familiar migrant from North America was found in Cueva Catedral. This bone is similar in length in *Compsothlypis americana* and *Dendroica magnolia* and, save for its different form, might be confused with them. The tibio-tarsus of *Mniotilta* is distinguished from that oı these two by stronger shaft, and distal broadening toward the extensor bridge, as well as by the broadened excavation between procnemial and ectocnemial ridges, differences arising from the climbing habit of the present bird.

CŒREBIDÆ

34. **Cœreba portoricensis** (Bryant)

Though the honey creeper is the most abundant of small birds in Porto Rico today, it is represented only by a broken cranium and part of a tibio-tarsus from Cueva Catedral, a fact due perhaps to the fragile nature of the bones in its skeleton. The cranium shows no appreciable difference from modern skulls. Superficially this cranium resembles that of small warblers in whose range Porto Rico is included. On careful comparison, however, *Cœreba* is found to differ from slender-billed warblers (*Mniotilta*, *Compsothlypis*, and *Dendroica*) in having the lachrymal region more expanded laterally, a broadening that includes the anterior end of the frontal adjacent to the lachrymal. This enlargement extends

as two lateral anterior protuberances on the frontal, at the cranio-facial hinge, that bound a distinct depression, rudely elliptical in outline, intruding slightly upon the posterior end of the nasal. In addition, the lachrymal in *Cœreba* is much larger than in warblers.

Icteridæ

35. **Agelaius xanthomus** (Sclater)

The yellow-shouldered blackbird was represented by a humerus in Cueva Clara and by assorted fragments from nine or more individuals in Cueva Catedral. The form of skull in this species is markedly different from that found in the *Agelaius phœniceus* group including the more slender-billed *A. tricolor*, as in *xanthomus* the premaxilla extends more nearly in the plane of the palate and is not abruptly deflexed to form a distinct angle at the corner of the mouth. The formation in *A. xanthomus* is thus similar to that in the genus *Icterus*. Premaxillæ of *xanthomus* from Cathedral Cave strongly suggest those of *Icterus portoricensis*, but on close scrutiny it is seen that *A. xanthomus* differs in being slightly broader and less attenuate apically, in having a broader, heavier nasal process, and in possessing a shorter, more rounded nasal opening. A distinct line in the narial opening marks the broken ankylosis of the internasal septum.

This species is common in open localities where palms growing on hill slopes offer suitable cover and nesting sites.

36. **Icterus portoricensis** (Bryant)

The tree-haunting oriole, still an abundant species in Porto Rican forests, suffered heavily from the depredations of owls inhabiting Cueva Catedral, as remains of twenty or more individuals, comprising a large number of bones, come from that cavern. A single femur encountered in Cueva Clara is taken as representing this species, although it is larger than normal. This oriole is of the type with elongated external narial aperture, resembling *I. wagleri*, from which, however, it differs in more slender, elongate premaxilla. The difference from such types as *I. galbula* and *bullocki* that have the narial aperture shorter and more rounded is marked. The processus angularis posterior in *I. portoricensis* is broad, strong, and much elongated, more so than in other orioles available at this time as skeletons. The cranium is distinguished by the thin outer margin of the processus zygomaticus squamosi that extends backward nearly to the end of the shallow temporal depression, by the smoothly rounded basitemporal plate, narrow frontal region between the orbits, and by the divergent positions of the foramina for the vena capitis that lie on the rim of the foramen magnum.

37. **Holoquiscalus brachypterus** (Cassin)

The Porto Rican blackbird, today common in the open fields of the lowlands, was represented only by a broken metatarsus from Cueva Catedral.

TANGARIDÆ

38. **Nesospingus speculiferus** (Lawrence)

Strange to state, the Porto Rican tanager, known as one of the rarest of native birds of the island, was the species most abundantly represented in Cueva Catedral, where remains of over one hundred individuals were identified. A few additional bones were encountered in Cueva Clara. In the large series from Cueva Catedral there is considerable variation in size, indicative of sexual differences that may be noted readily in examining a series of skins. Thus, in eighty-two premaxillæ certain individuals of maximum size may be set aside as unquestionable males. The nasal septum in *Nesospingus* (Fig. 24) has a tendency to ossify and become attached, as is shown by the raised line between the two narial openings. This internasal line broadens to form a small process just anterior to the plate of the ethmoid. Mandibles (Fig. 25) and fragments of the cranium represent this tanager without question.

Fig. 24

Fig. 25

Nesospingus speculiferus

Fig. 24. Lateral view of upper mandible, natural size. From Cueva Catedral

Fig. 25. Lateral view of lower mandible, natural size. From Cueva Catedral.

In identifying bones of the lower limb, femora, tibio-tarsi, and tarso-metatarsi there has been doubt in the assignment of many specimens. In *Loxigilla, Icterus,* and *Nesospingus* from Porto Rico these bones seem more or less similar and grade into one another in size and form almost imperceptibly, in spite of the fact that these genera represent three groups among the nine-primaried oscines. The specimens of these bones from Cueva Catedral have been allotted after prolonged study of minute differences but, in spite of the care used, I am not certain that part of those assigned to *Nesospingus* may not belong elsewhere. The distinction between *Nesospingus* and *Loxigilla* is especially puzzling.

The large number of bones of the Porto Rican tanager in the present collection may be explained readily when it is known that the birds gather in flocks at nightfall, and roost in chosen clumps of palms where their only shelter is in seed clumps, axils of leaves, the spathes surrounding seed heads, or the central spike. In such situations the birds make easy prey to night feeding owls. Once such a roost was located, it would

be easy for an owl to return again and again, so that the inroads of these rapacious birds may have had a decided effect upon the abundance of *Nesospingus*, or may indeed account for the scarcity of this bird.

While studying this material I had occasion to examine a body of *Nesospingus speculiferus* (U. S. National Museum, Cat. No. 225083) collected in Porto Rico on the mountain El Yunque in 1900, and preserved in alcohol by Dr. C. W. Richmond. As the species is rare in collections, even in the form of skins, the following notes on this dissection may be of interest.

The two portions of the muscle latissimus dorsi were contiguous throughout, with the line of demarcation between so slight that the two parts seemed almost fused. The anterior part arose from the outer margin of the dorsal extremity of the neural spine on the fourteenth cervical vertebra (the vertebra bearing the second free rib) and on the first dorsal immediately behind it. The posterior portion of the muscle had a similar origin on the four dorsal vertebræ that follow. There was no trace of attachment for the latissimus dorsi on the dorsal vertebra bearing the last pair of ribs (that do not reach the sternum), which was fused with the anterior end of the pelvis. The posterior half of the muscle was thin and attenuate, so that it was difficult to trace. The anterior portion was heavier and thickened appreciably toward the point where it separated from the body. The two parts narrowed rapidly toward this point, so that the resulting slip was not more than 1.5 mm. broad though the origin extended through a space of 15 mm.

Other points in the anatomy were developed as usual in the birds of this group. The gall-bladder measured 8 mm. in length, the cylindrical spleen 8 mm. long by 1.5 mm. in diameter. The intestine was wide and large throughout. Its total length was 190 mm., with a distance of 21 mm. between the insertion of the cæca and the anus. The paired cæca were cylindrical in form and measured 11 mm. long by 1 mm. in diameter.

39. **Spindalis portoricensis** (Bryant)

The Porto Rican spindalis was represented in Cueva Catedral by bones of ten or more individuals, and in Cueva Clara by two pairs of humeri. The species is common at present.

Fringillidæ

40. **Loxigilla portoricensis** (Daudin)

Fragments of several of these birds including two premaxillæ and seven lower mandibles were identified from Cueva Catedral. This grosbeak is a shy resident of hillside thickets.

41. **Tiaris olivacea** (Linnæus)

The abundant small grassquit (separated as the subspecies *bryanti* in Porto Rico) was represented by two humeri found in the deposits in Cueva Catedral. The species has the humerus more slender than in *Tiaris bicolor*, a form of which (subspecies *omissa*) also occurs on the island.

42. **Coturniculus savannarum** (Gmelin)

Two humeri of the grasshopper sparrow come from Cueva Clara. The insular form of this bird, locally common, is now known as *C. s. borinquensis* Peters.

Article V.—ALTITUDE IN COLORADO AND GEOGRAPHICAL DISTRIBUTION

By Frank E. Lutz

It is often desirable in studies of geographic distribution to have some short and usable expression for the general northern-ness or southern-ness, eastern-ness or western-ness of a species or group of species. The "geographic average" has been suggested[1] as such an expression. What was meant may be made clear by the following illustration.

A given species extends from Montana (about 47° N., 110° W.) to British Columbia (about 54° N., 124° W.), Oregon (about 44 N., 121° W.), and Colorado (about 39° N., 106° W.). Its "mid-latitude" is the average of the latitudes (47, 54, 44, and 39° N.) of these corners of its range, or 46.0° N. Its "mid-longitude" is found in a similar way to be 115.25° W. The "mid-range" of the species is, then, 46° N., 115.25° W. The mid-range of a species extending from Virginia to Florida, Louisiana, and Oklahoma is approximately 33° N., 87.5° W. These mid-ranges are directly comparable and we may say that the former species averages 13 degrees more northern and 27.75 degrees more western than the latter. The use of degrees of latitude and longitude instead of geographic names permits us to average also the extents of or limits of ranges.

The "mid-range" should not be confused with "center of population." If a species is very abundant in, say, British Columbia (about 54° N., 124° W.) and is found but rarely southeast to New Mexico (about 34° N., 106° W.), its mid-range would be halfway between these points (about 44° N., 115° W., in Idaho) but the center of population might be very close to, or even in, British Columbia. The "center of population" would probably be much more useful than "mid-range" but it does not seem to be possible to calculate it, for we do not have enough data concerning the density of population in every place of more than a few species.

It should also be kept in mind that, in certain cases, the mid-range is at a point where the species does not in fact occur. For example, if a species has a crescentic range, such as in Canada and southward along the Rockies and the Appalachians, the mid-range would be within the horns of the crescent, say in Iowa. Such a mid-range, however, would indicate a distribution that is in general more northern and more western than that of a species which occurs in the Gulf States and northward along the Mississippi River and the Atlantic coast.

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[1]Lutz, Frank E. 1921. 'Geographic Average, a Suggested Method for the Study of Distribution.' American Museum Novitates, No. 5.

Range in Degrees of Longitude	Range in Degrees of Latitude														
	0–2	3–5	6–8	9–11	12–14	15–17	18–20	21–23	24–26	27–29	30–32	33–35	36–38	39–41	Total
0— 8	97	89	41	24	13	3	1								268
9— 17	4	10	24	29	28	11	7		2						115
18— 26			1	6	7	18	14	3		2	1				52
27— 35			1	1	3	4	3		4	2	1	1			20
36— 44					3	3	1	2	6						15
45— 53					1	5	1		6	10	5				28
54— 62				1	1		3	1	2	1	2		1		12
63— 71						3	2	1	2		2			1	11
72— 80								2	2	1					5
81— 89									1				1	1	3
90— 98									13	3	1			1	18
99—107									2	2					4
108—116									9	3	2				14
Total	101	99	67	61	56	47	32	9	49	24	14	1	2	3	565

Table 1.—The relation between the extent of latitudinal range and that of longitudinal range. Based on Colorado plants. Ranges expressed in degrees.

The present paper is an application of the method of geographic averages to certain problems in connection with work which the American Museum's Department of Entomology has been doing in Colorado and adjacent states, but the data used here are for plants, not insects. This is partly because botanists have covered their field much better than have entomologists, so that it is relatively easy to get data concerning the distribution of plants, and partly because it is believed that the distribution of plants is a very important factor in the distribution of even those insects which are not phytophagous.

The data have been secured from Rydberg's 'Flora of Colorado'[1] by tabulating the distribution of species listed from Portulacaceæ to Fabaceæ, inclusive. There was no special reason for selecting this particular part of the flora; all that was wanted in this case was a random sample. Cultivated plants and introduced species were excluded and certain of the plants noted by Cary in his 'Biological Survey of Colorado'[2] were added. It is realized that such a sample would not be the best for all purposes. Selections on the basis of growth-habit (woody or herbaceous, annual or perennial, etc.) or of habitat (aquatic, xerophytic, etc.) or of other distinctions, such as date of flowering, promise interesting results but it is believed that the present selection is satisfactory for the purposes in mind, namely, studies of the general relations between latitudinal, longitudinal, and altitudinal (in Colorado) ranges. An attempt is also made to approximate a concrete expression for the rather indefinite "life zones" as given by Cary for Colorado.

RANGE

Table 1 presents the data concerning the extent of range, latitudinal and longitudinal, of 565 Colorado plants. The ranges of latitude are given in three-degree classes, while those of longitude are in nine-degree classes. There is a strong correlation (0.79 ± 0.01) between the two. In other words, a species that ranges far north and south is almost always wide-ranging in an east-and-west direction and vice versa. While this is what we might expect, the following factors should be taken into consideration.

All the species considered here are Colorado plants. On the one hand, more than a third of the species, as will be shown later, are restricted to the Colorado region and hence, having a small range in both latitude and longitude, greatly increase the correlation. On the

[1] 1906, Agric. Experiment Station, Colo. Agric. College, Bull. 100.
[2] 1911, U. S. Dept. of Agric., Bureau of Biological Survey, North American Fauna, No. 33.

Mid-latitude	Range in Degrees of Longitude													
	0–8	9–17	18–26	27–35	36–44	45–53	54–62	63–71	72–80	81–89	90–98	99–107	108–116	Total
55.0—56.9													3	3
53.0—54.9					1			1	1		2		1	6
51.0—52.9				1		4			1		4		7	17
49.0—50.9		1		2		2	2	1			8		3	19
47.0—48.9		1	2	2	2	12	1	2	3	1	2	4		32
45.0—46.9		9	12	4	3	2	3	2		1	2			38
43.0—44.9		20	20	4		4	1	3		1				53
41.0—42.9	1	19	9	2	3	2	4	2						42
39.0—40.9		11	4	1	4	2	1							23
37.0—38.9		6	3	2			1							12
35.0—36.9		5	1	1	2									9
33.0—34.9		10	1	1										12
31.0—32.9	2	7												9
Total	3	89	52	20	15	28	13	11	5	3	18	4	4	275

Table 2.—The relation between mid-latitude and the extent of longitudinal range, expressed in degrees. Based on Colorado plants having ranges of more than 100 sq. degrees. See also Table 3.

other hand, there is a high correlation, as will be shown later, between altitude and latitude, so that those Colorado plants, all coming from an altitude of at least 4,000 ft., that have a large latitudinal range extend into the north where a degree of longitude is not as large, measured in miles or meters, as it is farther south. Table 2 shows the relation between the mid-latitude and longitudinal range of 275 Colorado plants, each having a range of 100 square degrees or more; the correlation coefficient is .66 and the regression is not linear, as indicated by Table 3, which also shows in tabular form what the correlation coefficient expresses, namely,

Latitude	Kilometers in One Degree of Longitude	Average Longitudinal Ranges	
		Expressed in Degrees	Expressed in Kilometers
56	62.385	112.00	6987.120
54	65.567	80.50	5278.144
52	68.669	86.05	5908.967
50	71.687	76.00	5448.212
48	74.616	59.12	4411.298
46	77.453	34.32	2658.187
44	80.196	25.74	2064.245
42	82.840	26.07	2159.639
40	85.383	25.13	2145.675
38	87.821	22.00	1932.062
36	90.152	22.00	1983.344
34	92.373	15.25	1408.688
32	94.481	11.00	1039.291

Table 3.—The second column shows the length of one degree of longitude at the various latitudes indicated in the first column. The third and fourth columns show the average longitudinal ranges of Colorado plants falling in various mid-latitude classes indicated in the first column. The latter facts are derived from Table 2.

that the more northern the species the greater, on the average, is its longitudinal range when expressed in degrees. It would be difficult to determine the ranges in miles for each of these hundreds of species but Table 3 makes it clear that, on the average, the actual extent of range in the east-west direction is greater for those species whose mid-latitude is northern than for the more southern species. Table 4 confirms this on the basis of the maximum latitude attained by each species.

Tables 5 and 6 show the relations between altitudinal range in Colorado and the latitudinal and longitudinal ranges. The average altitudinal range, as shown by the data, is 3958 ft. but it should be remembered that this is the altitudinal range in Colorado, a state that

Maximum Latitude	Range in Degrees of Longitude													Average Longitudinal Range
	0–8	9–17	18–26	27–35	36–44	45–53	54–62	63–71	72–80	81–89	90–98	99–107	108–116	Total	
64—66		2	1	7	3	19	4	2	1	3	18	4	14	78	72.9
61—63									4					4	
58—60						1								1	
55—57				1		1	2	6						10	59.8
52—54		20	35	6	7	4	5	3						80	27.3
49—51		1	3		1	1								6	
46—48		31	11	4	3	2	2							53	20.8
43—45		15	1		1									17	15.1
40—42		5												5	
37—39	1	15	1	2										19	14.9
Total	1	89	52	20	15	28	13	11	5	3	18	4	14	273	

Table 4.—The relation between the maximum latitude attained by species and the extent of their longitudinal ranges, expressed in degrees. Based on Colorado plants having ranges of more than 100 sq. degrees.

Range in Feet of Altitude	Range in Degrees of Latitude														
	0–2	3–5	6–8	9–11	12–14	15–17	18–20	21–23	24–26	27–29	30–32	33–35	36–38	39–41	Total
0— 999			1												1
1000—1999	17	9	6	7	6	6		2	5	2			1		61
2000—2999	10	16	9	9	6	7	2		7	4				1	71
3000—3999	20	21	8	11	11	8	10	3	6	1	2			1	102
4000—4999	7	17	14	9	12	1	7	2	7	6	7				89
5000—5999	6	7	6	9	10	7	5	1	10	4	2		1		68
6000—6999	3	5	3	4	6	4	4		3	4	2	1			39
7000—7999	3	1	1	1	1	2	2		1						12
8000—8999	1						1								2
Total	67	76	48	50	52	35	31	8	39	21	13	1	2	2	445

Table 5.—The relation between the extent of altitudinal range in Colorado and that of latitude. Based on plants, including those of restricted range.

Range in Feet of Altitude	Range in Degrees of Longitude													
	0–8	9–17	18–26	27–35	36–44	45–53	54–62	63–71	72–80	81–89	90–98	99–107	108–116	Total
0— 999	1													1
1000—1999	35	12	3	1	1	3		2	1	2			1	61
2000—2999	37	13	3	5	1	5	1	1		1	1		3	71
3000—3999	53	21	12	2	3	3		3			2		3	102
4000—4999	34	22	9	4	2	4	2	1	4		2	1	4	89
5000—5999	21	15	7	2	3	7	6				4	2	1	68
6000—6999	14	5	4	3	4	1	3	1			3		1	39
7000—7999	4	3	3	1								1		12
8000—8999	1		1											2
Total	200	91	42	18	14	23	12	8	5	3	12	4	13	445

Table 6.—The relation between the extent of altitudinal range in Colorado and that of longitude. See Table 5.

Mid-altitude	Range in Degrees of Latitude														
	0–2	3–5	6–8	9–11	12–14	15–17	18–20	21–23	24–26	27–29	30–32	33–35	36–38	39–41	Total
14000–14999									1						1
13000–13999	2					2			2						6
12000–12999	7	3		1				2	2	1	1				17
11000–11999	13	10	4	2	2	1	2		3	2	2				41
10000–10999	9	8	10	3	2	3	3		11	5	3				57
9000– 9999	12	15	9	3	5		6		6	4					60
8000– 8999	20	12	13	10	5	6	4	1	4	3	3			1	82
7000– 7999	16	17	8	9	17	6	5		8	4	3	1	1	1	96
6000– 6999	8	14	9	14	13	13	7	1	3	3	2		1		88
5000– 5999	6	9	5	9	5	3	5	2	4						48
4000– 4999	1	2	2	3	5	3		2	1						19
Total	94	90	60	54	54	37	32	8	45	22	14	1	2	1	515

Table 7.—The relation between mid-altitude in Colorado and the extent of latitudinal range. Based on plants, including those of restricted range. See Table 8.

does not go much below 4000 ft. or much above 14,000 ft. If it were topographically possible, some of these plants would undoubtedly range much farther. This fact doubtless decreases the correlations shown by the data, $0.16 \pm .03$ between extent of altitudinal and latitudinal ranges and 0.13 ± 0.03 between extent of altitudinal and longitudinal ranges. However, it seems safe to conclude that the correlations between altitudinal and geographic ranges is significantly less than between latitudinal and longitudinal ranges. In other words, many species may range widely geographically without being particularly wide-ranging in altitude and vice versa.

		Range in Degrees of Latitude			
		0—8	9—20	21—41	Total
Mid-altitude	12000—14999	12 (50.0%)	1 (4.2%)	11 (45.8%)	24
	10000—11999	40 (40.9%)	23 (23.5%)	35 (35.7%)	98
	4000— 9999	132 (33.6%)	144 (36.6%)	117 (29.8%)	393
	Total	184 (35.7%)	168 (32.6%)	163 (31.7%)	515

Table 8.—An analysis of Table 7. See below.

The curves for both latitudinal and longitudinal ranges (see Table 1) are unilateral. Each starts off with a large number of species having very restricted ranges; each curve then falls until we come to a number of wide-ranging species, where it rises to a secondary peak. This secondary peak is most marked in the case of the extent of latitudinal range and is due to boreal-montane species. Table 7 shows the relation between the extent of latitudinal range and the mid-altitude of a species. One interesting feature of this relation is more clearly brought out in Table 8, where the extent of latitudinal range is given in classes so divided that each class contains approximately one-third of the total number of species. It will be noted that, among the plants having a mid-altitude of less than 10,000 ft., the species are about equally divided among the three classes but with a slight preponderance of species in the class having a moderate extent of latitudinal range. The case is quite different among the plants having a mid-altitude of 12,000 or more feet; 50% have an extremely restricted latitudinal range, 46% have a great latitudinal range, and only 4% are in the moderate class. It would seem that the plants in the higher parts of Colorado fall distinctly into two classes, those of very restricted range and those of very wide range.

These two extremes, however, balance each other to such an extent that there is no significant difference between the average extent of latitudinal range for different mid-altitudes.

Table 9 shows the relation between altitudinal range in Colorado and the mid-latitude for 227 plants having a geographic range of at least 100 square degrees. It will be seen that both extremely northern and extremely southern species have small average altitudinal ranges while the classes of medium latitude have average altitudinal ranges that are fairly uniformly about 4400 ft. It is well known and is further shown in

Mid-latitude	Average Altitudinal Range
53 to 56°	2833 ft.
49 52	4435
45 48	4448
41 44	4386
37 40	4409
33 36	3333
29 32	2900

Table 9.—The relation between mid-latitude and the average extent of altitudinal range in Colorado. Based on 227 plants having ranges of more than 100 sq. degrees.

detail elsewhere in this paper that southern species tend to be found at low altitudes and northern ones at high altitudes. The altitudinal ranges considered here are artificially cut off at about 4000 and 14,000 ft., the altitudinal boundaries of Colorado. It is quite probable that this is the chief explanation of the apparently reduced altitudinal ranges of northern and southern species, a reduction having no particular biological interest.

EXTREMES OF RANGES

As was shown in the general section on "range," species which extend into high latitudes tend to have wide longitudinal ranges. Figs. 1 to 5 illustrate diagrammatically the extreme ranges for various mid-altitude (in Colorado) classes; for further explanation, see page 350.

The curve for maximum latitude is very irregular, as is shown by Table 4. It may be that there is some biological reason for the accumulation of species at about 38°, 47°, 53°, and 65° latitude and the marked lack of species having northern limits at 50° and 59° latitude, but the irregularity of the curve is doubtless due in large part to the manner of compiling the data for, if a species is said to extend to British Columbia,

Maximum Altitude	No. of Species	Average Latitudinal Extremes	
		Northern	Southern
14000 ft. or more	9	61.0°	37.7°
12000 to 13999 ft.	47	57.7	36.7
10000 to 11999 ft.	72	55.4	36.2
8000 to 9999 ft.	71	51.4	33.8
6000 to 7999 ft.	36	46.8	31.6
Below 6000 ft.	10	45.2	29.9

Table 10.—The relation between the maximum altitude attained in Colorado and the average latitudinal extremes. Based on plants having ranges of more than 100 sq. degrees.

Mid-altitude	No. of Species	Average Latitudinal Extremes	
		Northern	Southern
13000 ft. or more	5	60.8°	38.0°
11000 to 12999 ft.	19	60.2	37.3
9000 to 10999 ft.	54	58.3	37.1
7000 to 8999 ft.	78	54.6	33.6
5000 to 6999 ft.	78	49.5	33.2
Below 5000 ft.	10	45.2	29.9

Table 11.—The relation between mid-altitude in Colorado and the average latitudinal extremes. Based on plants having ranges of more than 100 sq. degrees.

Minimum Altitude	No. of Species	Average Latitudinal Extremes	
		Northern	Southern
13000 ft. or more	1	65.0°	38.0°
11000 to 12999 ft.	4	62.0	38.0
9000 to 10999 ft.	25	60.6	37.2
7000 to 8999 ft.	50	56.0	35.9
5000 to 6999 ft.	48	53.5	35.5
Below 5000 ft.	97	50.8	33.5

Table 12.—The relation between the minimum altitude attained in Colorado and the average latitudinal extremes. Based on plants having ranges of more than 100 sq. degrees.

Maximum Latitude	No. of Species[1]	Average Altitude in Colorado		
		Maximum	Mid-	Minimum
North of 57.9° (Alaska, Greenland)	About 73	11404 ft.	9474 ft.	7688 ft.
49.0 to 57.9° (So. Canada, Labrador)	About 88	10054	7845	5988
37.0 to 48.9° (South of Canada)	About 77	8858	7100	5569

Table 13.—The relation between northern limit of range and average altitudes in Colorado. Based on plants having ranges of more than 100 sq. degrees.

Minimum Latitude	No. of Species[1]	Average Altitude in Colorado		
		Maximum	Mid-	Minimum
37.0 to 40.9° (Not South of Colorado)	About 129	10779 ft.	8844 ft.	7030 ft.
31.0 to 36.9° (So. of Colo., No. of Mexico)	About 57	10464	8110	6179
South of 31.0° (Mexico and Florida	About 55	8133	6352	5115

Table 14.—The relation between southern limit of range and average altitudes in Colorado. See Table 13.

[1]The number is not the same for each altitudinal class because records of "about" a given altitude were counted as mid-altitude and those of "up to" were counted as maximum altitude.

it was put down as extending to 54° latitude (about the middle of the collected area in British Columbia and falling in the class whose mid-point is 53°), while if it is said to extend to Alaska it was put down as extending to 65° latitude. Now, as a matter of fact, British Columbia and Alaska join each other and, combined, they extend from less than 50° to more than 70° latitude. Doubtless Colorado species are stopping off all along the line but, as the exact northern limit was not given, these mid-points were the only ones that could be used and they are fairly satisfactory when combined in averages with other similar mid-points. The same remarks apply to the data for minimum latitudes.

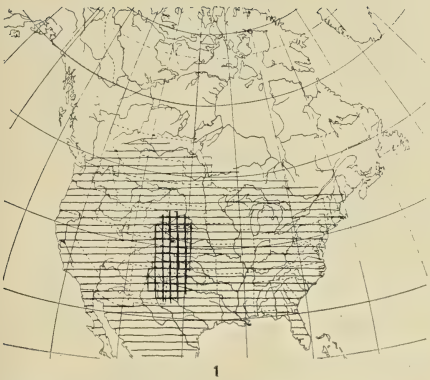
Tables 10 to 12 show the average northern limits and southern limits for the various altitudinal classes. As was to be expected, the higher the altitude the more northern are, on the average, both latitudinal extremes. The correlation coefficients are doubtless large but have not been calculated because of the irregularity of the data upon which they would be based. The averages obtained will be used in the discussion of life zones. Tables 13 and 14 show the complimentary relations.

ALTITUDE AND MID-LATITUDE

The most noticeable thing and the point most emphasized in studies of geographic distribution in mountainous regions is that the more northern species are found in the higher altitudes. Boreal species have southern extensions of their ranges along the north-and-south mountain ranges of North America and, since we take the tips of these often narrow extensions for the southern corners of the range in calculating mid-latitude, we do not get absolutely true expressions of the mid-latitude of the species. It is very desirable to have corrections for altitude in such cases.

It has been suggested, for example, by Hopkins in his papers on the "bioclimatic law," that one degree of latitude is equivalent to 400 ft. of altitude. It seems clear that this, even if it holds true in certain places, is not universal and I understand that Dr. Hopkins takes into account local modifying factors. Without attempting to establish any general law, I have analyzed the data at hand concerning Colorado plants, remembering that mid-latitude was calculated without corrections for altitude and that the altitude data are affected, as regards the minimum altitude of low-altitude plants, by the fact that Colorado does not extend much below 4000 ft.

It is clear that in such an analysis we must not include the species of very restricted geographic range. It has been shown above that half



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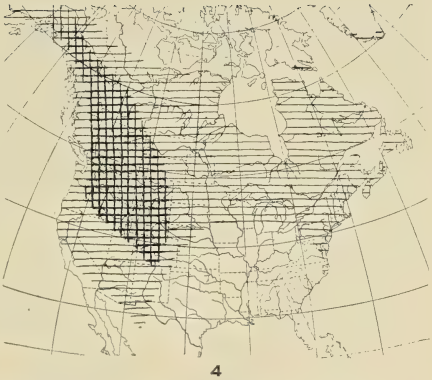

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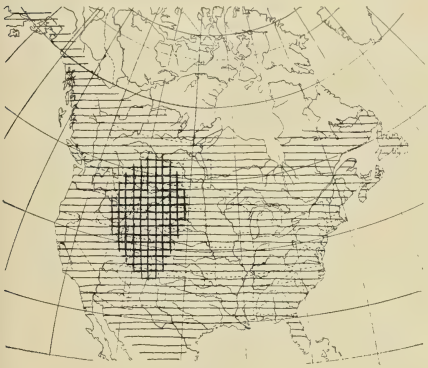

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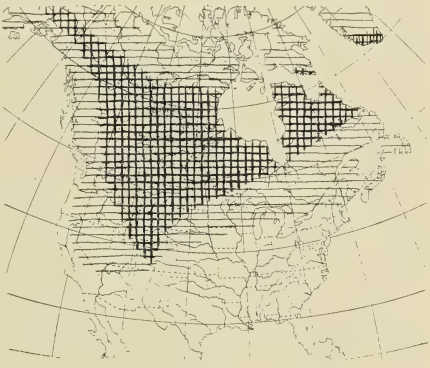

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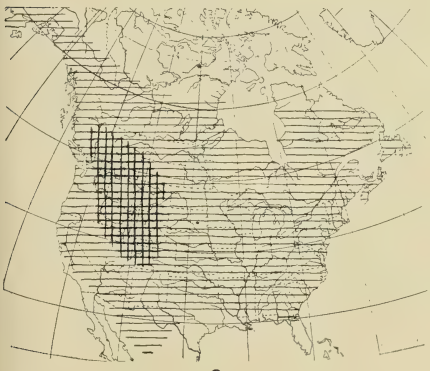

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Figs. 1–5.—Diagrams showing the relation between geographic range and mid-altitude in Colorado. Horizontal lines indicate the area containing at least one species of the given mid-altitude class. Heavier shading indicates the area containing at least half of the species of a given mid-altitude class. Fig .1: average mid-altitude, 4500 ft. Fig. 2: 6500 ft. Fig. 3: 8500 ft. Fig. 4: 10,500 ft. Fig. 5: at least 12,000 ft.

of the high-latitude plants in Colorado are confined to that region; that is, they have a mid-latitude of approximately 39°. If they were included, it would mask the real facts concerning the boreal nature of the other half of the montane species. The same is true of plants of very restricted geographic range occurring at other altitudes. After careful consideration of the frequency curves for extent of ranges and because round numbers appeal to one's sense of the fitness of things, I have confined the following analysis to those species having a geographic range of at least 100 square degrees, as determined by multiplying the extent of latitudinal and that of longitudinal range.

Figs. 1 to 5 illustrate diagrammatically the areas covered by plants having mid-altitudes in Colorado of about 4500, 6500, 8500, 10,500 and at least 12,000 ft. respectively. These diagrams were made up by connecting by straight lines the corners of the ranges as given by Rydberg. Of course the actual ranges do not have straight-line boundaries but the picture obtained by such a process indicates certain features of the actual facts. The diagrams of the areas (indicated by a combination of vertical and horizontal ruling) having at least 50% of the species contained in a given group seem to be most interesting. Such an area for the group of plants having a mid-altitude in Colorado of at least 12,000 ft. spreads out fan-like from Colorado to Alaska and Greenland. The corresponding area for the 10,500-foot group does not go to the East but follows the mountains to Alaska. Going to the other extreme, the corresponding area for the 4500-foot group is confined to the plains and in the eastward direction stops rather abruptly at 100° longitude. These diagrams should not be mistaken for "life-zone" maps and it should be remembered that they are based on straight-line diagrams of the ranges of from only ten to fifty-two plants in each altitude group. Rather more significant conclusions may be reached by the following use of mid-ranges and the correlation methods long employed in the statistical study of variation.

Table 15 shows the relation between mid-latitude and the maximum altitude attained in Colorado by each of 248 plants having a range of at least 100 square degrees, including species concerning which Rydberg merely says that they extend "up to" a given altitude. The correlation is 0.609 ± 0.027.

Table 16 shows the relation between mid-latitude and the minimum altitude at which 227 such plants are found in Colorado. The correlation is 0.515 ± 0.033.

Maximum Altitude	Mid-latitude													
	32	34	36	38	40	42	44	46	48	50	52	54	56	Total
14500						1	1		2	1	3		1	9
13500						1		6	2	1	4	2		16
12500			1		1	2	9	3	6	6	2	1		31
11500					2	1	3	3	4	3			1	17
10500				3	4	9	11	9	10	5	4	1		56
9500	1	2		2	6	9	12	7	1	2	1			43
8500	3	1		1	4	4	8	5	4					30
7500		2	4	2	6	3	1	4						22
6500	1	4	2	2		3	1							13
5500	2	2	1	2		3	1							11
Total	7	11	8	12	23	36	47	37	29	18	14	4	2	248

Table 15.—The relation between the maximum altitude attained in Colorado and the mid-latitude. Based on plants having ranges of more than 100 sq. degrees.

Minimum Altitude	Mid-latitude													
	32	34	36	38	40	42	44	46	48	50	52	54	56	Total
13500													1	1
12500							1							1
11500										1	1	1		3
10500								3	3	1	3	1		11
9500						1	2	1	5	3	1		1	14
8500	1				1	2	9	6	3	3	4	2		31
7500				2	1	4	4	3	2	2	1			19
6500					3	2	4	2	4	4				19
5500	3	1	2	1	4	3	4	6	1	2	2			29
4500	2	8	5	8	12	22	20	11	8	2	1			99
Total	6	9	7	11	21	34	44	32	26	18	13	4	2	227

Table 16.—The relation between the minimum altitude attained in Colorado and the mid-latitude. Based on plants having ranges of more than 100 sq. degrees.

Mid-altitude	Mid-latitude													
	32	34	36	38	40	42	44	46	48	50	52	54	56	Total
14500												1		1
13500							1		1				2	4
12500									1	2	3			6
11500						2		4	3		2	2		13
10500						1	8	4	6	5	5	1	1	31
9500					2	2	6	4	3	3	2	1		23
8500	1		1	2	1	6	8	3	4	5				31
7500	1		1	1	8	7	8	9	7	2	3			47
6500	3	4	1	2	5	11	15	8	3	1				53
5500		3	4	4	5	6	1	1	1	1				26
4500	2	2	1	2		3	1							11
Total	7	9	8	11	21	38	48	33	29	19	15	5	3	246

Table 17.—The relation between mid-altitude in Colorado and mid-latitude. Based on plants having ranges of more than 100 sq. degrees.

Table 17 shows the relation between mid-latitude and mid-altitude in Colorado of 246 such plants, considering that when Rydberg says a plant occurs at "about" a given altitude this is the mid-altitude in Colorado of that plant. This relation seems to be the most interesting of these three. The correlation is 0.602 ± 0.027, and, as the correlation ratio is 0.615, the regression may be considered to be linear.

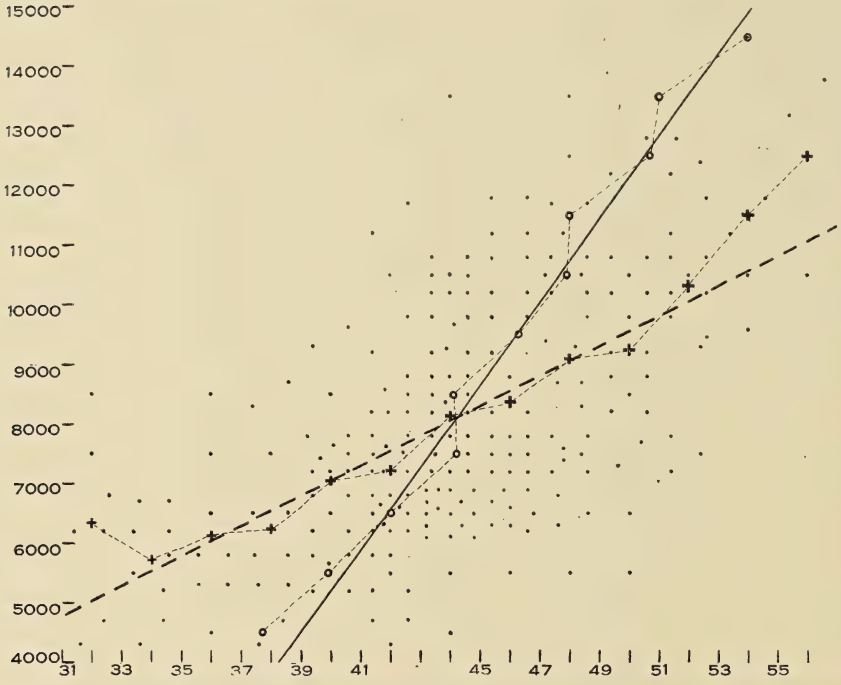

Fig. 6.—The relation between mid-altitude in Colorado and mid-latitude. Dots stand for individual species; circles and crosses, for averages. The heavy lines are regression lines drawn from the formulæ given below.

On the basis of linear regression in each case, we get the following regression formulæ.

Maximum altitude = 266.12 mid-latitude − 1644 ft.
Mid-latitude = 29.90 + .00140 maximum altitude.

Minimum altitude = 216.08 mid-latitude − 3156 ft.
Mid-latitude = 36.23 + .00123 minimum altitude.

Mid-altitude = 250.94 mid-latitude − 2991 ft.
Mid-latitude = 32.47 + .00145 mid-altitude.

The fit of the last set of regression lines to the averages is shown in Fig. 6.

Fig. 7.—Diagrammatic representation of the relation between the maximum altitude (upper line), mid-altitude (middle line), and minimum altitude (lower line) in Colorado and the mid-latitude. See below for further explanation.

It is perhaps permissable to average the two formulæ of each of these sets in order to get the formulæ of single lines that will fit fairly well the averages of both rows and columns. Such averages are

Mid-latitude = .002035 Maximum altitude + 23.48 degrees
= .001943 Minimum altitude + 31.69 degrees
= .002121 Mid-altitude + 27.00 degrees

Mid-altitude	Mid-longitude 127	123	119	115	111	107	103	99	95	91	87	Total
14500						1						1
13500							1	1		1	1	4
12500				1			1	1	2	1		6
11500		2		4	1	2		1	3			13
10500	1	4	1	7	3	3	3	5	4			31
9500		3	2	9	3	1	3		1		1	23
8500		3		9	8	3	3	2		2	1	31
7500		1		8	9	14	7	4	3	1		47
6500		1	1	10	4	13	9	6	5	2	2	53
5500		1		1	2	7	7		3	3	2	26
4500						1	3	4	2	1		11
Total	1	15	4	49	30	45	37	24	23	11	7	246

Table 18.—The relation between mid-altitude in Colorado and mid-longitude. Based on plants having a range of more than 100 sq. degrees.

The formula of a line referred to the average mid-altitude and mid-latitude of this material and based on one degree of latitude being equivalent to 400 ft. of altitude is

Mid-latitude = .0025 Mid-altitude—23.93 degrees.

This is not nearly as good a fit to the facts as the formula for mid-altitude given above.

The three formulæ supposed to represent fairly well the facts concerning the conditions in Colorado, as found by a study of these plants, give the lines shown in Fig. 7. In this figure I have taken the liberty of extending the lines to altitudes which do not exist in Colorado. If such extensions are justified, they indicate that, were a portion of Colorado

Mid-altitude	Average Mid-latitude	Average Mid-longitude
13500 ft.	51.0°	95.0°
12500	50.7	99.7
11500	48.0	108.8
10500	47.9	109.1
9500	46.3	111.9
8500	44.1	109.3
7500	44.2	107.1
6500	42.0	105.3
5500	39.9	102.4
4500	37.7	99.4

Table 19.—Showing the average mid-latitudes and mid-longitudes for various classes of mid-altitudes in Colorado. Based on 246 plants having ranges of more than 100 sq. degrees.

at sea-level, the plants there would have a mid-latitude of about 31.7°. Unpublished data in my possession concerning plants near sea-level from Texas to Lower California indicate that this is probably true. In the Merriam system they would represent the Lower Sonoran flora, not, in fact, considered by the Biological Survey to be present in Colorado. If the Colorado mountains ran much higher than they actually do, there would doubtless be plants at 16,000 ft. altitude and the extension of the maximum-altitude line indicates that they would have a mid-latitude of about 50°. Of course, it is never safe to extend generalizations far beyond our facts but, if the facts are determined for a large number of mountainous regions, the determinations being based in each case on a large number of species, we may be able to arrive at a safe generalization.

ALTITUDE AND MID-LONGITUDE

Table 18 gives data based on 246 Colorado plants, each having a geographic range of at least 100 square degrees, for the relation between their mid-altitude in Colorado and their mid-longitude. The correlation

is only +0.16 but the regression is not linear and the correlation ratio is about .39. The average mid-longitude for each thousand-foot class of mid-altitude (disregarding the highest, as one species is manifestly too few to form the basis of an average) is given in Table 19 and they indicate the existing relation. On the average, the plants of low altitudes have mid-longitudes of about 100° in other words, about the eastern border of Colorado. As we go up the mountains the species become more western until we reach about 9500 feet and then they become progressively more eastern until, on the average, they reach about 95°.

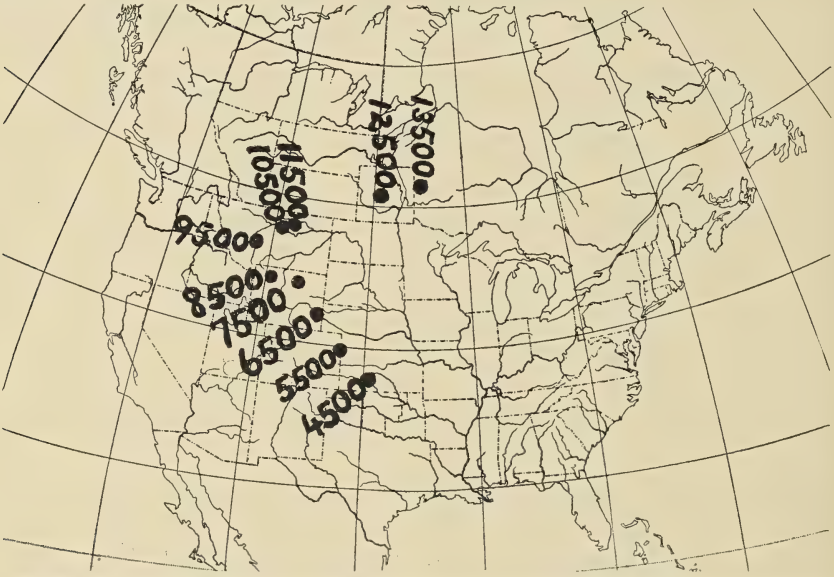

Fig. 8.—The mid-ranges of plants belonging to the various mid-altitude (in Colorado) classes indicated by the numerals.

ALTITUDE AND MID-RANGE

Table 19 and Fig. 8 shows the average mid-range of the species in each thousand-foot class of mid-altitude from 4500 to 13,500. Compare also Figs. 1 to 5, which show diagrammatically the extent of ranges. All of these show that, as we go upward in Colorado from a basic elevation of about 4000 ft., the species become more northwestern in their distribution until we reach an elevation of about 9500 ft. This is probably due to the influence of distinctly Rocky Mountain species. Then there is a sudden turn in the trend, the species becoming more and more northeastern, due, apparently, to the influence of transcontinental boreal-montane species.

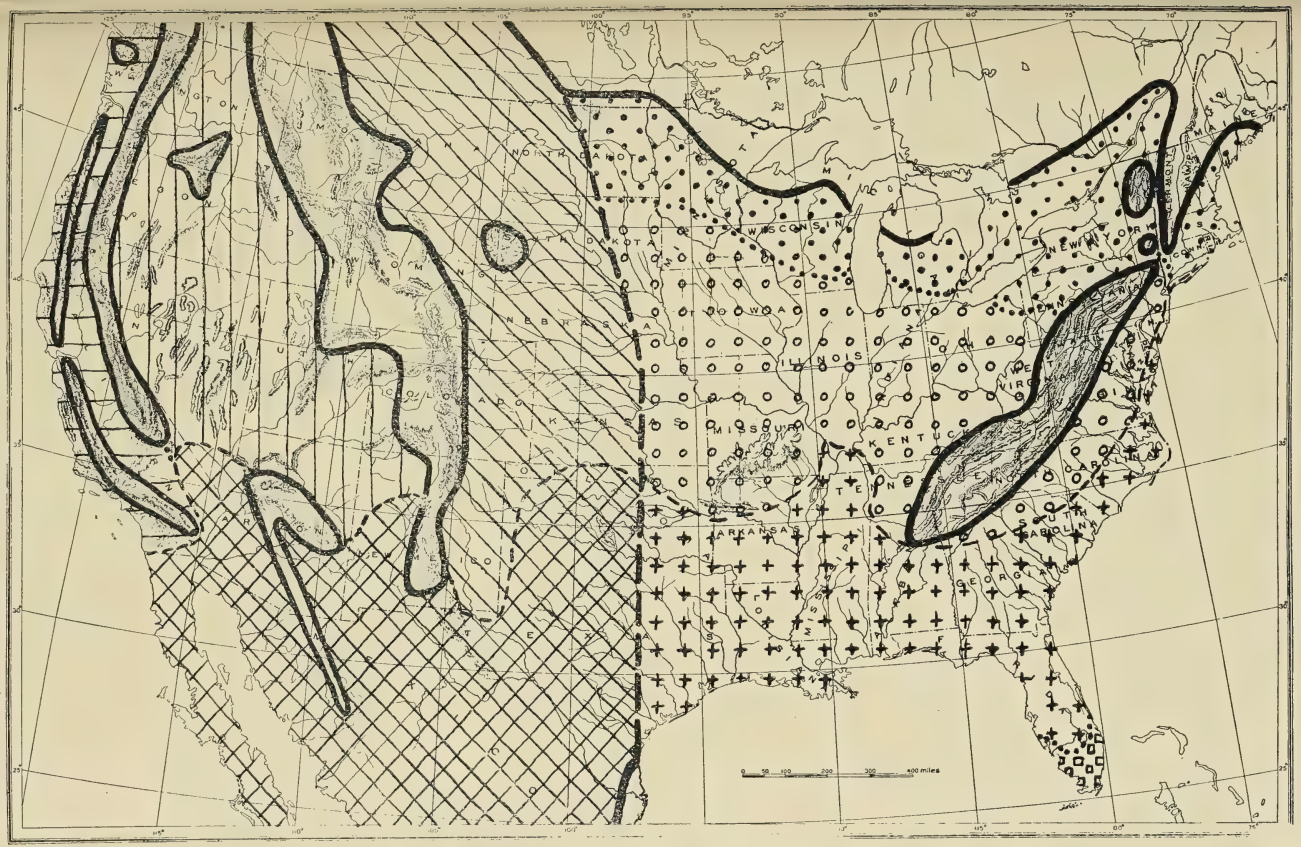

Fig. 9.—Diagrammatic representation of the Allen system of biotic areas in the United States.

Only the Warm Temperate Subregion (boundaries indicated by heavy solid lines) is subdivided in this map and locations of the areas are only approximate, especially in mountainous regions. The Humid Province is shaded by various kinds of dots and the Arid Province by lines (boundary between them indicated by heavy broken line). Boundaries between Subprovinces are indicated by light broken lines. Appalachian Subprovince: Alleghanian Fauna, plain dots (found also south on the mountains); and Carolinian Fauna, circular dots. Austroriparian Subprovince: Louisianian Fauna, cross dots; and Floridian Fauna, square dots. Campestrian Subprovince; Great-Plains District, sloping lines; Great Basin District, vertical lines; Pacific Coast District, horizontal lines. Sonoran Subprovince: lines sloping in two directions.

LIFE ZONES

Livingston and Shreve[1] have recently published a most excellent study of the distribution of vegetation in the United States and of certain climatic factors that are undoubtedly important in connection with it. In the concluding pages they say (p. 528):

> From the preceding discussion, and from considerations presented in Part II, it appears that the system of life-zones worked out by Merriam and now rather widely used in a descriptive way, especially by the United States Biological Survey, will require much modification before it may become at all satisfactory to a serious student of etiological plant geography. It is extremely unfortunate that the actual data on which this system was originally based, and on which its applications are based in current descriptions, do not exist in the published literature. Neither Merriam nor any of his followers has thus far attempted to present the actual basis for the system in form such that a critical study of its good and bad features may be undertaken. Perhaps this may be a main reason why the whole subject of the climatic relations of floral and faunal areas has received so little attention at the hands of students who are able and willing to undertake the complex analyses which are involved in such a subject. The publication of the charts without the data on which they were based, together with the general and official adoption of the system by the United States Biological Survey, have given this important problem the appearance of having been satisfactorily solved—of being a closed subject. Those who have employed this zone system have either refrained from any discussion of its good and bad characteristics, or else they have merely taken the standpoint of advocates, and the lack of the numerical data that are absolutely necessary for a critical study has tended strongly to discourage such inquiries. Also, a sort of authoritative atmosphere that seems to hang over government publications in general, together with the apparent authority and dogmatism that invariably go with well-printed (and especially colored) charts, to the exoteric reader, tend in the same direction, to retard real progress.

Apparently Livingston and Shreve had overlooked, as have so many others, the work of Dr. Allen. A part of the Allen system is diagrammatically shown in Fig. 9. The question as to Dr. Allen's share in originating the zones which have since been worked out in such detail by the U. S. Biological Survey as a result of Dr. Merriam's stimulating influence is, I am sure Dr. Allen would say, of little importance. In his paper read before the Tenth Congress of the American Ornithologists Union, held in Washington, D. C., November 15–17, 1892, he spoke with his characteristic kindness and modesty as follows.[2]

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[1]1921. 'The Distribution of Vegetation in the United States, as Related to Climatic Conditions.' Carnegie Inst. of Washington, Publication No. 284.

[2]Quoted from The Auk, X, pp. 143, 144. The 1871 paper to which reference is made was in Bull. Mus. Comp. Zool., II, No. 3; the 1878 one was Bull. U. S. Geol. and Geogr. Survey (Hayden), IV, pp. 338–344. In 1892 Dr. Allen published a detailed study on 'The Geographical Distribution of North American Mammals,' Bull. Amer. Mus. Nat. Hist., IV, pp. 199–243, Pls. v–viii (colored distribution maps). Dr. Merriam's papers appeared at approximately the same time: 1890, North American Fauna, No. 3; 1891, North American Fauna, No. 5; 1892, Proc. Biol. Soc. Wash., VII, pp. 1–64, with colored map.

In comparing the present scheme of faunal areas of North America with those employed by Dr. Merriam in his recent well-known admirable papers on the geographical distribution of North American mammals, so frequently cited in the preceding pages, it will be noticed that there is a striking agreement in their number and boundaries, although a few new minor divisions have here been introduced; yet the terms employed for their designation are to a great extent different. As already intimated, the present system of classification and nomenclature is a further development of that first instituted by me in 1871, and used later in 1878, and now carried out in greater detail and extended to the whole North American Continent. The present revision of the subject is therefore not to be looked upon as unfriendly criticism of Dr. Merriam's classification and nomenclature, which he evidently adopted provisionally, selecting such terms as would suffice to clearly indicate the areas under discussion; his attention was given mainly and most successfully to an elucidation of the facts of distribution; a detailed consideration of the nomenclature of the subject was outside of his special field.

Much more important for the science of distribution are the differences between the two systems as published. Of these, Dr. Allen said in the same paper (pp. 147–148):

The first discrepancy between Dr. Merriam's classification and my own that requires notice is in respect to the primary divisions of the North American Region, which he first termed "Provinces" and later "Regions," with the prefixes "Boreal" and "Sonoran" respectively for the "Cold Temperate" and "Warm Temperate" *Subregions* of the present writer. The use of Boreal, however, as shown above, was not an innovation; but the term "Sonoran" was used in a new and greatly extended sense, the term Sonoran being applied to a region identical in geographical extent with the Warm Temperate,—a designation previously used for the same area,—and hence including the region east of the Mississippi (as well as that west of it), from the Great Lakes and southern New England south to Florida and the Gulf Coast. The terms "Sonoran" and "Sonoran Province" were used as early as 1866 by Prof. Cope, and also later by Cope, Heilprin, and others, for a region of comparatively small extent, consisting of Sonora and adjoining portions of Arizona and New Mexico. In 1887 Heilprin extended the region to include "the peninsula of Lower California, the State of Sonora in Mexico, New Mexico, Arizona; and parts, not yet absolutely defined, of Nevada, California, Texas, and Florida," and modified its title by calling it the "Sonoran Transition Region." The Sonoran Province or Region of these authors is thus not at all the "Sonoran Region" of Merriam, which is an area of much greater extent and of higher rank. The term Sonoran, used in this extended sense, seems at least inappropriate if not misleading, as there are few if any strictly "Sonoran" types represented in that portion of the United States situated to the eastward of the Mississippi River. The more descriptive and appropriate designation of "Warm Temperate" is therefore preferred for the region in question, since it not only has priority, but is in harmony with the terms Arctic, Cold Temperate, and Tropical, used currently for other coördinate areas of the continent.

Another, and perhaps the only other, important discrepancy between Dr. Merriam and myself is in respect to the primary subdivisions of the Warm Temperate or "Sonoran" Subregion. Here the difference is in respect to classification, Dr. Merriam dividing the Warm Temperage into two transcontinental divisions which he

terms respectively "Upper" and "Lower Sonoran"; while according to my best judgment the primary division is in a meridional line into an eastern and a western division, which I have termed respectively Humid and Arid Provinces, borrowing the terms from Dr. Merriam, who has used them in the same geographical sense but not in the same nomenclatural relation, as already shown in preceding pages. As the evidence, pro and con, has already been submitted (see *antea*, pp. 128–131, and Bull. Amer. Mus. Nat. Hist., IV, pp. 230–232), it is unnecessary to rediscuss the matter here.

The interesting difference pointed out in the last quoted paragraph may be expressed by saying that, according to the Allen system, humidity is considered to be a more potent factor controlling distribution within the borders of the United States than is temperature, at least outside of the higher mountains. Dr. Allen also divided his Campestrian subprovince longitudinally into Great-Plains, Great-Basin, and Pacific-Coast districts, a point that the Biological Survey apparently considers of minor importance. I am attempting to analyze, with these points in mind, the distributions of more than a thousand species and, although the analysis has not yet reached a point that will permit definite statements, the indications are that Dr. Allen was right in each case.

However, to return to the quotation from Livingston and Shreve, it may be that these authors were so engrossed in their important work on climatic factors that they have naturally failed to recognize fully the importance of other sorts of work. The early theories as to the climatic bases of the life zones that have been adopted by the Biological Survey may be left out of account. What has been accomplished is that the Survey's field men have done an unsurpassed piece of work in accumulating data concerning the distribution of mammals and birds (incidentally other forms also), especially in western United States. They have correlated these data with their accepted zones and these are the data upon which the zones are now based.

It is true that apparently the Biological Survey zones are now based on species primarily, leaving future work to discover the exact climatic factors controlling the distribution, rather than mapping climatic factors first and subsequently discovering the way in which these factors have, if they have, influenced distribution. Really, this method of attacking the problem seems rather logical. What seems more serious is that these zones are primarily nothing but an indefinite expression of the northern-ness or southern-ness (in mountains the highness or lowness) of a species or of a fauna or flora.

In suggesting[1] the geographic average as a method for the study of distribution I said:

[1]1921, American Museum Novitates, No. 5.

Students of the distribution of animals and plants have divided North America, especially United States, into sections, within each of which the fauna or flora, or both, is believed to be more or less homogeneous and more or less distinct from other, corresponding sections. I must confess that these sections seem to me less distinct than they once did. It is characteristic of human psychology that we classify and make categories where there are no definite classes or categories. We speak of north, east, south, and west. When we go more deeply into the subject we speak of northeast, southeast, and so on. At sea, however, we box the compass by such gradual steps that we have a continuous circle with no separate divisions. This does not mean that "north," "east," and so on are not convenient and useful conventions but, as a matter of fact, they are only very general terms. In the same way, there is no definite "arctic-alpine," "austral," and so on, and a definiteness can only be maintained for these zones by a special selection of "indicator species" or something of that sort. If this procedure be accepted, almost any sort of system of zones may be devised by selecting appropriate "indicators."

On the other hand, some system is convenient and useful. The carefully investigated system of Merriam, based on the fundamental studies of Allen, has been widely accepted. Can we take the proposed biotic areas and get some concrete expression for them that will be based on the biota as a whole? This expression should, if possible, be something that will help us to say with a fair degree of assurance that a given limited area or a given species belongs in this section or that.

In that paper I made provisional suggestions as to the latitudinal averages for life zones along the Atlantic Coast. It was necessary there to make guesses as to how the Biological Survey would place certain species or areas. In Colorado we have the advantage of a published Biological Survey report. Although what follows was intended to be held until our report on the western work of the American Museum's Department of Entomology had been completed, it may be of interest to publish in this connection the analysis, as far as made, of at least the mid-latitudes for the Colorado zones.

Cary in his report on 'A Biological Survey of Colorado'[1] defines the life zones of that state in two ways: (1) by a table showing the extreme altitudinal limits of zones in Colorado, and (2) by citing what he considers to be typical animals and plants of each zone. The table of altitudes seems to be very carefully worked out, different limits being given for northeast and southwest exposures as well as for northern and southern Colorado. Furthermore, this table was doubtless drawn up as the result of many observations in the field in which the record made in each case was that of the general impression created by the environment. It is quite probable that the table represents the Biological Survey's ideas of life zones more accurately than do the individual species of plants which were doubtless selected as typical species by men who were not specialists in botany and who had not given careful attention to the distribution of these plants outside the area covered by their field work.

[1]1911, U. S. Dept. of Agriculture, Bureau of Biological Survey, North American Fauna, No. 33.

	Data from Cary's	Upper Sonoran	Transition	Canadian	Hudsonian	Arctic-Alpine
Maximum Altitude	Table	6600 ft.	8175 ft.	10475 ft.	11425 ft.	
	Plants	7196	9240	10750	12500	13087 ft.
Mid-altitude	Table	**5300**	**7388**	**9325**	**10950**	**12700**
	Plants	**5718**	**7346**	**8813**	**10477**	**10940**
Minimum Altitude	Table		6600	8175	10475	11425
	Plants		5500	6906	9364	8714

Table 20.—Altitudinal averages for various "life-zones" in Colorado. Based on Cary's table of altitudes and Rydberg's data concerning Cary's "typical" plants.

		Upper Sonoran	Transition	Canadian	Hudsonian	Arctic-Alpine
Averages based on regression lines and Cary's table of altitudes	Maximum Latitude	46.5°	52.7°	56.0°	58.8°	61.0°
	Mid-latitude	**39.7**	**43.0**	**45.6**	**47.8**	**50.6**
	Minimum Latitude	31.5	34.2	36.0	37.0	37.9
Averages based on Rydberg's data concerning Cary's "typical" plants	Maximum Latitude	47.9	51.9	59.2	57.7	60.9
	Mid-latitude	**39.4**	**42.7**	**46.4**	**46.1**	**49.2**
	Minimum Latitude	30.7	34.3	36.4	36.7	37.0

Table 21.—Latitudinal averages for various "life-zones." Based on data as indicated in the table.

Averaging the altitudinal limits given in Cary's tables for the various zones and estimating average mid-altitudes, we get the results shown in Table 20. The table also shows for comparison the average altitudes of the plants cited by Cary as typical of each zone, the averages being calculated from data given by Rydberg in his 'Flora of Colorado.' It will be seen that there is fairly close agreement in the lower zones but not in the upper, strengthening the belief that the Survey's field men were not altogether fortunate in their selection of "indicator" or "typical" plants, especially in the higher zones which were doubtless not studied by them as thoroughly as were the lower ones.

Given the average altitude in Colorado of a group of species, it is easy to calculate the average mid-latitude of that group from the regression formulæ given on page 355. The results of such calculation are given in Table 21. This table also shows the average mid-latitudes of the plants which Cary cited as typical of the various life zones in Colorado. It will be noticed that, on the average, the plants cited as typical of Hudsonian are not more northern than those cited as typical of the Canadian. Believing that, as stated above, Cary was not particularly fortunate in the selection of certain of these plants, I would be inclined to lay greater stress on the mid-latitudes derived from the altitudes given in his table.

Table 21 also suggests probable average maximum and minimum latitudes for the various zones, based on both altitude and indicator plants. As explained in the section on Extremes of Ranges, the data on which these averages are based is not entirely satisfactory and I have not worked out the formulæ of the regression lines. The figures given are probably, however, fairly close approximations.

If the reasoning followed here be justified, it seems possible to make a "first approximation" to a definition of the latitudinal element involved in the conception of these zones. It may be said that species in a typical Upper Sonoran region have an average mid-latitude of about 40°; Transition, 43°; Canadian, 46°; Hudsonian, 48°; Arctic Alpine, 50° N. The average for the Arctic Alpine is based on rather too few cases to be good even for a first approximation; probably 52° is nearer right and, since the "zones" themselves are convenient conventions rather than real entities, we might agree to move "Hudsonian" up to an average mid-latitude of 49° N. Then we could easily remember that, starting with Upper Sonoran at 40°, the average mid-latitude of each succeeding zone is three degrees more northern. Judging from the average mid-latitude (31° N.) of 69 plants cited by Bailey as typical of the Lower Sonoran in New Mexico, the break in average latitude between it and the Upper Sonoran of Colorado is as great as that between Upper Sonoran and Hudsonian in Colorado. Upper Sonoran sweeps

boldly to Canada in the survey maps, while Lower Sonoran is not recognized as a zone in Colorado although a number of Bailey's typical Lower Sonoran plants do occur there. Perhaps there is a distinct break between the distribution of species to which Allen, in the paper quoted above, insisted the term Sonoran should be restricted (a large part of the Lower Sonoran of Merriam) and what Merriam called Upper Sonoran. On the other hand, it may be that the conception of zones in Bailey's 'Biological Survey of New Mexico' is different from that in Cary's 'Biological Survey of Colorado,' a point which is being investigated.

It happens that 68 of the plants considered in this paper are recorded from Fort Collins, Colorado, by Rydberg. They have an average mid-latitude of 42.5° N. This is, on the scale just suggested, rather close to typical Transition. Cary's map puts Fort Collins in Upper Sonoran near its junction with Transition. "Samples" which I have in the same way from other Colorado points show the following average mid-latitudes. Grand Junction, 39.2°; Lamar, 39.8°; both close to the suggested typical Upper Sonoran. Trinidad, 40.3°; Boulder (plains), 40.6°; Durango, 40.8°; Colorado Springs, 41.0°; slightly northern but still good Upper Sonoran. Mancos, 41.6°; getting on toward Transition. Walsenburg, 42.1°; more southern that Fort Collins (42.5°) but verging on Transition. Ouray, 44.4°; Pagosa Springs, 44.6°; more northern than typical Transition but not yet Canadian. Steamboat Springs, 45.3°; fairly good Canadian. Tennessee Pass, 47.9°; either typical Hudsonian or a little too southern, depending on the convention adopted.

Now, each of these averages is based on too few species to give good statistical results but they will serve as illustrations. It will be noted also that mid-longitude has not been considered but neither does the Merriam system take it into account except for the secondary division along the 100th meridian. The illustrations clearly show how gradually one zone merges into another and indicate that few places are typically one zone or another. Such being the case, some may doubt the desirability of retaining the zonal names at all. If we want an expression for the northern-ness or southern-ness of the group of species living in a given place, for the purpose of telling farmers what crops are likely to succeed there or for any other purpose, it might be better to go directly and rather more accurately at the task and determine the average mid-latitude of the group. Such average mid-latitudes could be plotted on a map and places having mid-latitudes of about the same value could be connected by iso-some-name-or-other lines. Such a map would be more definite than one painted in five colors, but whether it would be of greater practical use than a pentamerous system would depend somewhat on the purpose in mind.

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Article VI.—THE FAMILY DEINODONTIDÆ, WITH NOTICE OF A NEW GENUS FROM THE CRETACEOUS OF ALBERTA

By W. D. Matthew and Barnum Brown

I.—Introductory note.
II.—Distinctive Characters of the Megalosaurs, Cœlurids, Ornithomimids, and Deinodonts.
III.—Chronological List of Described Species of Deinodontidæ and Ornithomimidæ.
IV.—Provisional Systematic Arrangement.
V.—Remarks upon the Nomenclature of the Deinodontidæ.
VI.—A New Genus of Carnivorous Dinosaurs from the Cretaceous of Alberta.

I.—INTRODUCTORY NOTE

This is the first of a series of preliminary notices to be published by Mr. Brown and myself to place upon record various contributions to a knowledge of the Cretaceous Dinosaurs resulting from the preparation of the collections secured in Alberta by the Museum parties of 1910 to 1915 under Mr. Brown's leadership. It had been planned that these results should be studied and published by him, but owing to his absence from the Museum for some years past, mostly on field work abroad, his researches have been long delayed. Some obvious preliminary results we have thought advisable to publish now, postponing the more complete research and publication of the material until Mr. Brown's return to the Museum enables him to resume his more intensive studies upon the several groups of Cretaceous dinosaurs.

As should appear from the situation above outlined, the junior author should be credited with the new evidence and data placed upon record, as the results of his splendidly successful series of expeditions in the Western Cretaceous formations. The senior author is chiefly responsible for the interpretation of the data, the revision of previous conclusions and taxonomy, and for various possible errors which will later be corrected in the extended researches planned by his absent friend and colleague, with whose approval and in the interest of the American Museum these contributions are placed upon record.—W. D. M.

II.—DISTINCTIVE CHARACTERS OF THE MEGALOSAURS, CŒLURIDS, ORNITHOMIMIDS AND DEINODONTS

As a result of twenty-four years work the American Museum has now on exhibition a magnificent series of skulls and skeletons which can be fully and directly compared. They are as follows:

MEGALOSAURIDÆ

Allosaurus, complete skeleton and two skulls, hind limbs, etc.

CŒLURIDÆ

Ornitholestes (=*Cœlurus*), skeleton.

ORNITHOMIMIDÆ

Struthiomimus, one complete and two incomplete skeletons.

DEINODONTIDÆ

Gorgosaurus (=*Deinodon*), three nearly complete skeletons, two skulls.

Albertosaurus (?=*Deinodon*), skull, hind limb, tail.

Tyrannosaurus, skeleton, skull, pelvis and hind limbs.

The above specimens are on exhibition, and the distinctive characters stated in the lists on the following pages can readily be checked up and verified by anyone visiting the hall. There are in addition many specimens prepared but not at present exhibited, notably two very good skeletons of *Allosaurus* and two of *Gorgosaurus*, a partial skeleton of *Tyranosaurus* and numerous less complete specimens of all the genera listed, and of others some of which are undescribed.

On the basis of this series the distinctive characters of these four groups can be clearly seen. The Deinodontidæ in particular can be adequately distinguished and their systematic position clarified.

1.—The Megalosaurid Group of the Jurassic

Megalosaurus—Allosaurus—Ceratosaurus

This group has been very fully described, so far as the American genera are concerned, by Mr. Gilmore in his highly authoritative and admirably written and illustrated memoir on the Carnivorous Dinosaurs in the U. S. National Museum.[1] While we fully agree with most of Mr. Gilmore's conclusions therein set forth, there are a few points on which, after careful consideration of his evidence and argument, we are unable to adopt his views. Among these differences are the inclusion of the deinodonts in the Megalosauridæ, the retention of the Ceratosauridæ as a separate family, and the dropping of the well-known name *Allosaurus* in favor of *Antrodemus*. The objections to these points of procedure will be stated later.

The characterization of this group as here given rests primarily upon *Allosaurus*, secondarily upon *Ceratosaurus*, both known from complete skeletons. *Megalosaurus*, although discovered nearly a century ago, is still imperfectly known and there are some peculiarities about the known parts that suggest that it is really not closely related to the American genera, and is an early stage in the evolution of the very extraordinary group from the Lower Cretaceous of North Africa that Strömer has recently characterized under the name of Spinosauridæ. The reference of the American genera to the Megalosauridæ we regard as provisional.

The characters of the group as thus based are:

1.—Moderate to large size and rather massive proportions.
2.—Skull relatively large, teeth large, jaw long and deep. Fenestræ large, arcades moderately heavy. Anterior teeth somewhat U-shaped, both crests tending to become posterior, unreduced in size.
3.—Quadrate loosely united to quadratojugal, rather short, extending strongly backwards as well as downwards.
4.—Considerable movement between frontal and parietal.
5.—Cervicals of moderate length.
6.—Fore limb moderately reduced, powerfully proportioned.
7.—Manus short and spreading with large powerful claws, the outer digits reduced and vestigial to a varying degree.
8.—Ungual phalanges of manus strongly curved, moderately compressed.
9.—Pelvic elements usually separate. Ilium high anteriorly with long and massive peduncle. Ischium with moderately heavy shaft, expanded distally into a massive thickened head.
10.—Tibia shorter than femur, pes rather short, massive or of moderate proportions.

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[1]Gilmore, 1920, U. S. Nat. Mus. Bull. 110.

11.—Three subequal functional metatarsals, the shafts unreduced and not strongly appressed, of moderate length, the distal ends convex both ways. Digit I reduced to a distal vestige of the metatarsal, appressed against the shaft of mc. II with phalanges retroverted. Digit V a proximal splint.

12.—Phalanges of pes short and stout, the unguals moderately curved, uncompressed.

13.—Tail long, of many vertebræ, the distal caudals elongate, the prezygapophyses prolonged anteriorly.

Ceratosaurus differs from *Allosaurus* chiefly in four characters, the median frontal horn, the union of the metatarsals into a single bone, much as in the penguin, the union of the pelvic bones, and the decidedly less reduction of the external digits of the manus. The second and third characters do not involve any very marked difference in the form or proportions of the bones thus united and, while they may be characteristics of the genus and not merely of the individual due to age, yet they do not in our view involve any such wide osteological diversity as would warrant using them in family differentiation. The median horn of *Ceratosaurus* is a good generic distinction, but it is not at all likely that it would be a family character. The difference in the manus is the one really important distinction and here *Ceratosaurus* represents a decidedly more primitive stage in a line of specialization apparently somewhat different. As it is a contemporary of *Allosaurus*, this can be viewed partly as a structurally ancestral stage, partly as a divergent specialization, but it does not appear to us to be comparable to the diversity between *Ornitholestes*, *Struthiomimus*, and *Gorgosaurus*, which represent three distinct divergent lines of specialization in the manus. Taken all together, the differences between *Ceratosaurus* and *Allosaurus* do not appear to be more fundamental than those that distinguish *Deinodon* from *Tyrannosaurus*, *Monoclonius* from *Triceratops*, or *Corythosaurus* from *Trachodon*. They are of not more than sub-family value.

The substitution of *Antrodemus* for *Allosaurus* does not appear to be warranted at present, although future discovery of topotypes may prove it correct. *Antrodemus* is based upon an incomplete vertebral centrum, undoubtedly of a large theropod dinosaur from the "Morrison" formation of Middle Park, Colorado. No topotypes are known, and the vertebrate fauna from this vicinity is unknown. Without such topotype evidence we believe it is unsafe to conclude that the *Antrodemus* type is generically identical with *Allosaurus*. It may be provisionally so regarded, but a provisional reference is not sufficient ground to change the nomenclature. The type of *Allosaurus* is hardly more definitely determinable than that of *Antrodemus*, as Mr. Gilmore points out. But it is supported by adequate topotypes, among which is the fine skeleton

which Gilmore describes and figures so fully in his memoir. It seems better, therefore, to retain *Allosaurus* until adequate topotypes of *Antrodemus* have been obtained.

It is important to point out that in the differences between *Allosaurus* and *Ceratosaurus* we have apparently a guide to the tendencies of specialization in this family. The pes, as one would expect in a massively proportioned animal of this type, tends to consolidate the metatarsals into a single bone, stout and massive, the median element unreduced. This could not possibly lead into such a specialized type as is seen in the deinodonts and ornithomimids, which finds its analogy among rodents, marsupials, and birds in long, slender-footed, and comparatively small animals of leaping or cursorial adaptation. The manus, on the other hand, more specialized in *Allosaurus*, is a broad, short, spreading affair, not at all reduced in relative size compared with that of *Ceratosaurus* and having an important prehensile function. The further specialization here would tend apparently to two widely divergent, grasping digits on a moderately large and very powerful limb. The clue to the derivation of the deinodont manus may be found in either the megalosaurid or cœlurid type, but only through a marked reduction in size, which would hardly be expected in gigantic predaceous beasts and is not indicated in the megalosaurs. The tail of the megalosaurids is primitive but shows conditions that might lead into the peculiar specialization seen in the cœlurids, deinodonts and ornithomimids. Perhaps the most significant differences are seen in the pelvis, which in the deinodonts is very much nearer to the cœlurid and ornithomimid type than it is to the megalosaurid construction. The megalosaurs are nearer the sauropoda in their pelvic construction than are the other three families. On the other hand, there are no very obvious characters in the skull of the megalosaurs, which would preclude regarding them as the primitive ancestral group from which the deinodonts were derived.

2.—The Cœlurid Group of the Jurassic

Ornitholestes and *Cœlurus*

Mr. Gilmore has given very strong reasons for regarding *Ornitholestes* as a synonym of *Cœlurus*, and there can be no doubt that they are closely related. The characters of the cœlurid group can, therefore, be defined from *Ornitholestes*, and its status and affinities estimated.

The redescription by Osborn[1] presents the principal characters:

[1]Osborn, 1917, Bull. Amer. Mus. Nat. Hist., XXXV, pp. 733–771.

1.—Small size and slender proportions.
2.—Skull relatively small, teeth small, compressed, the premaxillary teeth somewhat reduced and of U-shaped cross-section. Jaw short, not deep.
3.—Quadrate closely sutured to quadratojugal, elongated, and extending forward and downward (owing to reduced relative length of jaw).
4.—No fronto-parietal movement.
5.—Cervicals long and slender.
6.—Fore limb not greatly reduced, bones long and slender throughout.
7.—Manus peculiarly specialized, mc. I very short and stout, divergent, mc. II and III long, slender, parallel, III greatly reduced in diameter; distal ends of metacarpals heavily grooved. All phalanges very long and slim. The metacarpals have the same proportions as in *Allosaurus* but the phalanges are of wholly diverse type.
8.—Ungual phalanges of manus greatly compressed, strongly curved.
9.—Pelvic bones united. Ilium elongate, extended far forward and decurved anteriorly, without distinct peduncle. Ischia slender, long, flattened distally but not expanded.
10.—Tibia somewhat longer than femur, pes very long and slender, isotridactyl.
11.—Three long slim metatarsals, separate, somewhat appressed, median metatarsal not reduced proximally, vestigial 1st and 5th digits unknown, probably as in Megalosauridæ.
12.—Ungual phalanges of pes of moderate length and curvature, not compressed.
13.—Tail elongate, not fully known but the distal caudals appear to be interlocked by prolongation anteriorly of the prezygapophyses.

The complete knowledge of the ornithomimid type shows that "*Ornitholestes*," as is recognized by Osborn (1917, p. 733), can no longer be understood as ancestral to it. This is especially seen in the fore limb, which is quite as much specialized but in a different manner. Nor is there anything in the pes that especially suggests an ancestral stage of the peculiarly specialized ornithomimid pes, which, as Gilmore has shown, had already appeared in the Lower Cretaceous. It is none the less true that, except for the fore limb, we might regard *Cœlurus* as not far from the ancestral type and that it may be considered as a collateral, although clearly not a direct ancestral, stage. But it would seem better to retain it in a separate family (Cœluridæ) for the present.

As compared with *Compsognathus*, *Cœlurus* is much more specialized. The Solenhofen skeleton shows, besides the three functional digits on the pes, a moderately reduced first and a vestige of the fifth; the manus has also three functional and two vestigial digits. The pubis is broad, the ischium very slender; many other details would no doubt show the far more primitive character of this little dinosaur. While it may be ancestral structurally to *Cœlurus*, no especial evidence is apparent in *Compsognathus* of the specializations peculiar to the cœlurid group and, again, being not far from contemporary it cannot be a direct ancestor.

Its relations to the megalosaurs are not very close, and it seems better to hold it as the type of a distinct family, Compsognathidæ.

3.—The Ornithomimid Group of the Cretaceous

Cœlosaurus, Ornithomimus, and *Struthiomimus*

It will hardly be open to question that these three genera form a closely allied natural group. Whether they should or should not be held distinct is at present a matter of opinion. The family may be characterized on the basis of the *Struthiomimus* skeleton described by Osborn as follows:

1.—Moderate size and slender proportions.
2.—Skull relatively small, toothless, orbital fenestra very large, jaw short and shallow.
3.—Quadrate closely sutured to quadratojugal, elongated, extending forward and downward.
4.—Unknown.
5.—Cervicals very long and slender.
6.—Fore limb slender but much elongate throughout.
7.—Manus peculiarly specialized, mc. I–III of equal length and thickness, mc. I divergent at distal end, appressed medially to mc. II, mc. III parallel but not appressed, phalanges greatly elongate. Distal ends of metacarpals all with convex heads.
8.—Ungual phalanges of manus moderately compressed, elongate, not strongly curved.
9.—Pelvic bones united. Ilium without peduncle, elongate and decurved anteriorly, ischium long, slender, flattened and decurved, moderately expanded at tip.
10.—Tibia longer than femur, metatarsals long, phalanges of moderate proportions.
11.—Metatarsals II and IV long, slim, subequal, median metatarsal broader at distal end but the shaft greatly reduced in the distal portion, trigonal, the inferior sides closely appressed to the lateral metacarpal shafts, in the proximal portion reduced to little more than a thread, partly concealed between the lateral shafts; the head a little enlarged but enclosed dorsad and plantad by the much larger heads of the lateral metatarsals. The distal ends of the lateral metatarsals are convex both ways, that of the median plano-convex. Vestigial 1st and 5th metatarsals as in Megalosauridæ, but further reduced or sometimes ? absent.
12.—Phalanges of pes of moderate length, the unguals rather short and not strongly curved or compressed.
13.—Tail elongate, the distal caudals strongly interlocked by prolongation of the postzygapophyses.

Cœlosaurus antiquus Leidy

Types.—(1) A complete tibia. Described and figured by Leidy, 1865, Smithsonian Contrib., 192, p. 100, Pl. iii, fig. 3. (2) Proximal and distal ends of tibia, distal end of lateral metatarsal, median and lateral proximal phalanges, all of one individual. Described and figured

by Leidy, *ibid.*, p. 101, Pl. XVII, figs. 6–11. Cope in 1868 referred the second specimen to "*Lælaps*," under the name of *L. macropus*. In the light of present knowledge it appears more probable that Leidy's original reference should be sustained.

Horizon and Locality.—Cretaceous greensands of New Jersey from Burlington and Monmouth Co. respectively.

So far as one can judge from the types, it would appear that this genus is closely allied to *Struthiomimus* Osborn and *Ornithomimus* Marsh, and perhaps identical with one or both. The type specimens are hardly less characteristic than the type of *Ornithomimus* and, if *Struthiomimus* is to be abandoned, as Gilmore advocates, on the ground that no adequate generic distinctions from *Ornithomimus* have been shown to exist, it would seem that the logical procedure would be to abandon both genera in favor of *Cœlosaurus*, on the ground that there is no known distinction at all between them. At all events, it would appear that Gilmore's ornithomimid bones from the Maryland Cretaceous could with somewhat better probability be referred to Leidy's genus than to the Western *Ornithomimus*, typically of much later age than the Arundel and later than the Jersey greensands.

4.—The Deinodont Group of the Cretaceous

Deinodon, including *Gorgosaurus* and *Albertosaurus; Dryptosaurus; Tyrannosaurus*, including *Dynamosaurus*

This group includes the large Upper Cretaceous dinosaurs. *Gorgosaurus* and *Albertosaurus* are very probably identical with *Deinodon*, and *Dynamosaurus* with *Tyrannosaurus*. *Dryptosaurus* is provisionally held distinct from *Deinodon*, which it much resembles. The essential features of this group are:

1.—Gigantic size and massive proportions.

2.—Skull relatively large with long deep jaw and large teeth. All fenestræ more or less reduced and arcades massive. Anterior teeth of U-shaped cross-section, (both crests posterior) the form changing progressively to the compressed oval section of the posterior teeth, with anterior and posterior serrate crest. Premaxillary teeth in the above genera much reduced in size.

3.—Quadrate closely united to quadratojugal, elongate, extending backward and downward.

4.—No fronto-parietal movement.

5.—Cervicals short and wide.

6.—Fore limb greatly reduced in relative size, moderately slender throughout.

7.—Manus peculiarly specialized, mc. I very short and stout, mc. II much longer, mc. III vestigial, distal ends of metacarpals deeply grooved, phalanges rather short.

8.—Ungual phalanges of manus strongly curved and much compressed.

9.—Pelvic bones usually solidly united. Ilium elongate, extended far forward and decurved anteriorly with very short peduncle, ischium flattened distally and decurved, not expanded at the tip.

10.—Tibia and femur of subequal length, pes stout and massive and of moderate length.

11.—Lateral metatarsals massive, moderately long, median metatarsal broader than either at distal end, but the shaft greatly reduced, in the distal portion trigonal, the inferior sides closely appressed to the lateral metatarsal shafts, in the proximal portion reduced to a very slender rod between the lateral shafts; the head a little enlarged but enclosed dorsad and plantad by the large heads of the lateral metatarsals. The distal ends of the lateral mestarsals are convex both ways, that of the median plano-convex

12.—Phalanges of pes massive and rather short, the unguals moderately curved, uncompressed.

13.—Tail elongate, the distal caudals strongly interlocked by prolongation of the prezygapophyses.

The above analysis of characters shows that the deinodonts, although paralleling the megalosaurs in their huge size, massive proportions, short neck and large head, differ from them and resemble the cœlurids and ornithomimids in the construction of the pelvis and the elongate quadrate. The pes has the very peculiar and specialized character of the Ornithomimidæ very exactly reproduced, save for the greater massiveness of all its elements; the manus is nearer to that of the Cœluridæ in some respects than to the megalosaurs, despite the diversity in the length of the phalanges, but might almost equally well be regarded as a specialization from that of *Allosaurus*. A review of the characters indicates that this group is not derived from the megalosaurs but from some primitive cœlurosaurian with the specialized pes of the Ornithomimidæ, but with the fore limb constructed more as in Cœluridæ or in *Allosaurus*, although smaller and with the phalanges less elongate than in *Cœlurus*. Such a type would probably be a slender, small, swift-footed animal, for only in such a type can one understand the evolution of the remarkable specialization of the pes. The subject of the affinities and origin of the various groups of theropod dinosaurs will be ably and thoroughly discussed in an essay by Doctor von Huene to be published elsewhere, and the foregoing data, based upon comparison of the theropod skeletons on exhibition in the American Museum, are intended only to present the reasons for the taxonomic arrangement here adopted.

The point which we principally desire to make clear is that upon the above evidence the Deinodontidæ must be regarded as a distinct and well-characterized family paralleling the megalosaurs but not derived from them, and that they cannot be included in that family as has been the general custom.

III.—CHRONOLOGICAL LIST OF AMERICAN CRETACEOUS DEINODONTS AND ORNITHOMIMIDS

Name as originally proposed, author and date	Formation and Locality	Nature of Type or Co-types	Present Reference
Deinodon horridus Leidy, 1856	Judith R., Mont.	teeth	*Deinodon horridus*
Cœlosaurus antiquus Leidy, 1865	Greensand, N. J.	tibia, foot bones	*Cœlosaurus antiquus*
Lælaps aquilunguis Cope, 1866	" "	parts of skeleton	*Dryptosaurus aquilunguis*
" *macropus* Cope, 1868	" "	foot bones, etc.[1]	*Cœlosaurus* (?) *antiquus*
Fam. Dinodontidæ Cope, 1866			Deinodontidæ
Aublysodon mirandus Leidy, 1868	Judith R., Mont.	teeth	= *Deinodon horridus*
Lælaps explanatus, Cope, 1876	" "	"	= (?) *Dromæosaurus* sp.
" *falculus* Cope, 1876	" "	"	= "
" *incrassatus* Cope, 1876	" "	"	= *Deinodon* (?) *horridus*
Aublysodon lateralis Cope, 1876	" "	"	" "
Lælaps cristatus Cope, 1877	" "	"	?*Dromæosaurus cristatus*
" *hazenianus* Cope, 1877	" "	"	= *Deinodon* (?) *horridus*
" *lævifrons* Cope, 1877	" "	"	*Dromæosaurus lævifrons*
Zapsalis abradens Cope, 1877	" "	tooth	Incertæ sedis, cf. *Dromæosaurus*
Dryptosaurus Marsh, 1877, type *Lælaps aquilunguis*			*Dryptosaurus*
Allosaurus medius Marsh, 1888	Arundel, Md.	tooth	(?) *Dryptosaurus medius*
Cœlurus gracilis Marsh, 1888	" "	"	(?) *Dromæosaurus gracilis*

[1] Co-type of *Cœlosaurus antiquus*.

Ornithomimus velox Marsh, 1890	Denver, Colo.	pes	*Ornithomimus velox*
" *tenuis* Marsh, 1890	Judith R., Mont.	? metatarsal III	*Struthiomimus tenuis*
" *grandis* Marsh, 1890	" "	? "	*Deinodon* (?) *horridus*
Fam. Ornithomimidæ Marsh, 1890			Ornithomimidæ
Fam. Dryptosauridæ Marsh, 1890			=Deinodontidæ
Ornithomimus sedens Marsh, 1892	Lance, Wyo.	part skeleton	*Ornithomimus sedens*
" *minutus* Marsh, 1892	Denver, Colo.	(?) metapodial	Indeterminate
Aublysodon amplus Marsh, 1892	Lance, Wyo.	tooth	=(?) *Tyrannosaurus* sp.
" *cristatus* Marsh, 1892	" "	"	" "
Manospondylus gigas Cope, 1892	Lance, S. Dak.	two vertebral centra	Indeterminate
Dryptosaurus kenabekides Hay, 1899	Judith R., Mont.	teeth	=*Deinodon horridus*
Ornithomimus altus Lambe, 1902	Belly R., Alberta	hind limb	*Struthiomimus altus*
Tyrannosaurus rex Osborn, 1905	Hell Cr'k, Mont.	part skeleton	*Tyrannosaurus rex*
Dynamosaurus imperiosus Osborn, 1905	Lance, Wyo.	" "	=*Tyrannosaurus rex*
Albertosaurus sarcophagus Osborn, 1905	Edmonton, Alta.	skull	(?) *Deinodon sarcophagus*
Fam. Tyrannosauridæ Osborn, 1906			=Deinodontidæ
Gorgosaurus libratus Lambe, 1914	Belly R., Alta.	skeleton	(?) *Deinodon libratus*
Struthiomimus Osborn, 1917, type *O. altus* Lambe, topotype a complete skeleton			*Struthiomimus*
Ornithomimus affinis Gilmore, 1920	Arundel, Md.	foot bones	(?) *Cœlosaurus affinis*

	Comanchic or Lower Cretaceous	Upper or True Cretaceous					
	Barrémian-Urgonian	Upper Senonian			Danian		
	Arundel Md.	Judith R. Montana	Belly R. Alberta	Upper Greens'd N. J.	Edmonton Alberta	Lance Wyo., Mont.	Denver Col.
Suborder Goniopoda Cope (Theropoda Marsh in part)							
1. Family Deinodontidæ Cope							
a. Subfamily Deinodontinæ (Dryptosauridæ Marsh)							
Deinodon horridus Leidy		×					
Dryptosaurus aquilunguis (Cope)				×			
" *medius* (Marsh)	×						
Gorgosaurus libratus Lambe			×				
" *sternbergi*, new species			×				
Albertosaurus sarcophagus Osborn					×		
b. Subfamily Tyrannosaurinæ Osborn							
Tyrannosaurus rex Osborn						×	
c. Subfamily Dromæosaurinæ							
Dromæosaurus albertensis			×				
" *lævifrons* (Cope)		×					
? " *cristatus* (Cope)		×					
?*Zapsalis abradens* (Cope)		×					
?*Dromæosaurus gracilis* (Marsh)	×						
2. Family Ornithomimidæ Marsh							
Cœlosaurus antiquus Leidy				×			
? " *affinis* Gilmore	×						
Struthiomimus altus (Lambe)			×				
" *tenuis* (Marsh)		×					
Ornithomimus velox (Marsh)							×
" *sedens* (Marsh)						×	

IV.—Provisional Systematic Arrangement

In the table opposite the indeterminate types and synonyms are omitted; a number of genera of very doubtful validity are provisionally retained, and a number of provisional allocations of species and genera are marked with a query.

V.—Remarks upon the Nomenclature of the Deinodontidæ

It should first be pointed out that Cope's name Dinodontidæ was the first family name to be applied to a carnivorous dinosaur. It antedates Megalosauridæ by four years and is based upon an unquestionably valid genus. But there is no need to discuss whether or not it should be used in place of Megalosauridæ—as it should, according to the usage of many palæontologists[1]—for the two families appear to be distinct.

Cope's original characterization of the family Deinodontidæ[2] was as follows: ". . . . The family Dinodontidæ . . is characterized by its contractile, raptorial claws and slender digits, and compressed sabre-shaped teeth." This definition was intended to distinguish the family from the herbivorous dinosaurs. The family Megalosauridæ was proposed by Huxley four years later.

Marsh[3] characterized the "Dryptosauridæ" as follows: "Including the large carnivorous forms of which only imperfect specimens have been found but sufficient to indicate that they are distinct from the Megalosauridæ of the European Jurassic. Limb bones hollow. Fore limbs very small. Feet digitigrade with prehensile claws." The Ornithomimidæ he characterized at the same time, referring them to the Ornithopoda (=Iguanodontia): "Limb bones hollow. Fore limbs very small; hind limbs of avian type. Feet digitigrade and unguiculate." Two years later[4] he transferred them to the Theropoda. In 1895[5] he somewhat expanded his definition of the Dryptosauridæ as distinct from the Megalosauridæ, but there is nowhere any reference to the Deinodontidæ or indication of the position to which he assigned the genus *Deinodon*. It may be assumed that he accepted Cope's mistaken conclusion that the generic name was preoccupied and the family name therefore untenable.

In this connection it may be well to call attention to the fact that Cope in 1866[6] divided the Dinosauria into two primary (subordinal) groups:

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[1] *Vide* discussion in Palmer's 'Index Generum Mammalium.'
[2] Cope, 1866, Proc. Acad. Nat. Sci. Phila., XVIII, p. 279.
[3] Marsh, 1890, Amer. Journ. Sci., XXXIX, p. 424.
[4] Marsh, 1892, Amer. Journ. Sci., XLIII, p. 451.
[5] Marsh, 1895, Amer. Journ. Sci., L, p. 493.
[6] Proc. Acad. Nat. Sci. Phila., XVIII, p. 317.

1. Goniopoda; types, *Lælaps* and probably *Megalosaurus.*

2. Orthopoda; types, *Scelidosaurus, Hylæosaurus, Iguanodon,* and *Hadrosaurus.*

He subsequently[1] added *Cœlosaurus* Leidy and *Poikilopleuron* Deslongchamps to the Goniopoda, but excluded *Compsognathus,* referring it to a third group, the Symphypoda. The distinctions lay in the characters of the tibio-tarsal joint. *Megadactylus* (*Anchisaurus*) he tentatively associated with the Symphypoda, of which the types are *Ornithotarsus* Cope 1869 (which? = *Hadrosaurus*) and *Compsognathus.* (This very unnatural association is based upon the supposed anchylosis in both of the astragalus with the tibia.)

It would appear, therefore, that Cope's suborder Goniopoda includes the families Deinodontidæ, Megalosauridæ and Ornithomimidæ, as represented by the genera then known.[2] It differs from Marsh's Theropoda in that it excludes the Triassic dinosaurs. It may prove to be a tenable and useful group name.

Orthopoda is clearly delimited to cover what was then known of the ornithischian dinosaurs and considerably antedates both *Ornithischia* Seeley and *Predentata* Marsh.

The Symphypoda includes *Compsognathus* and the Triassic dinosaurs (we may omit *Ornithotarsus* as a very fragmentary type whose position was misunderstood).

Now, it is a point of interest that Cope's instinct for comparative anatomy had enabled him to sense the real affinities of the various types of dinosaurs even though he was unable to define them; for the stated distinctions between these groups are worthless. But his arrangement of 1868 is a better one than Marsh's classification, made twenty years later and based upon vastly better material.

A few further notes appear to be necessary to defend the ordinal and subordinal terms used in this connection.

1.—Dinosauria Owen, 1842, was based upon *Iguanodon* and *Megalosaurus,* i.e., upon representatives of both the saurischian and ornithischian divisions, which are now regarded as distinct orders. It cannot, therefore, according to the customs of nomenclature, be limited to the Saurischia as Abel has recently suggested.[3] It must be used to cover

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[1]Cope, 1868, Journ. Acad. Nat. Sci. Phila., XIV, p. 100.

[2]Also *Poikilopleuron,* which is regarded by von Huene as related to the plateosaurs; but Cope's inclusion of this genus, if based on Deslongchamps' description, must have been wholly provisional and did not really affect his concept of the group.

[3]Abel, 1916, Naturwiss. Woch., XXXII, p. 469–474. The rule regarding names of groups of higher than family rank is as follows: "La loi de priorité est applicable aux noms de familles *ou de groupes plus élèves,* tout aussi bien qu'aux noms de genres et d'espèces *à la condition qu'il s'agisse de groupes ayant même extension.*" International code, 1892. The A. O. U. code has substantially the same provision regarding scope. If the law of priority is to prevail in groups of higher than family rank on the condition that the group names have exactly or substantially the same scope, it is obvious that it is not permissible to alter radically the scope of such terms; nor does zoölogical usage sanction such alterations, although it does not appear to be directly forbidden by the codes.

substantially what it was proposed to cover, and to limit the term Dinosauria Owen to the Saurischia would be to remove the major part of what he included under it (*Iguanodon*, etc.) and limit it to the minor part (*Megalosaurus*), plus a group (Opisthocœlia=Sauropoda), which he included under another order (Crocodilia). Abel's proposal appears to be technically improper and very undesirable, because it is very convenient to retain the term Dinosauria, although NOT as an ordinal name but as a convenient term to cover the whole group of reptilia to which it has been customarily applied, and which have a good deal in common although now fully recognized as pertaining to two distinct orders. As thus used, "dinosaurs" would be largely analogous to "pachyderms" among the mammals, a most useful term although not now understood as an ordinal one.

2.—SAURISCHIA Seeley appears to be the first and only name that has been proposed to cover the two groups currently known as Theropoda and Sauropoda, and which, as has been most fully demonstrated by von Huene, require ordinal separation from the ornithischian group.

3.—Seeley's ORNITHISCHIA, while an admirable correlative term for Saurischia, is antedated by Cope's Orthopoda with the same scope. Seeley's term antedates Marsh's Predentata, which is in current use and, like Seeley's term, admirably descriptive of an essential character of the entire group.

4.—In the subordinal grouping of the Saurischia, Marsh's arrangement has been shown by von Huene and others to be an unnatural one. We do not altogether accept von Huene's view that the primary division is into Cœlurosauria and Pachypodosauria, nor on the other hand does Jaekel's arrangement of Therophagi and Allophagi, the latter equalling Sauropoda+Plateosauridæ, the former including all the rest, appear to be very satisfactory. The fact appears to be that all the Triassic dinosaurs share in common a series of characters, which while doubtless mostly primitive, are quite clearly diagnostic, and separate them from the specialized groups of the later Mesozoic. Of the latter, the Sauropoda can in practice be most clearly set off as a group apart; the remainder (Megalosauridæ, Spinosauridæ, Cœluridæ, Deinodontidæ, Ornithomimidæ) might be united under Cope's term Goniopoda, if von Huene's more phyletic classification is not sustained. Where we know so little about the true phylogeny as with the dinosaurs it seems advisable to be conservative and base our classification upon concrete facts of structural characters more than upon somewhat conjectural views as to phyletic relations. Such procedure will be more likely to make for permanency in the nomenclature.

Deinodon Leidy, 1856, had for genotype *D. horridus* of the Judith River, Montana. This was the first genus of the Upper Cretaceous carnivorous dinosaurs to be described. It is based upon a number of more or less fragmentary teeth, figured by Leidy in his memoir on the Judith River. Leidy originally regarded them as all belonging to the same species, but subsequently adopted Cope's suggestion that those of U-shaped cross-section were of a different genus, which Leidy named *Aublysodon*. Cope rejected the name "*Dinodon*" as a homonym of *Dinodus*—which it is not; the derivation of the two words is different—and proposed *Lælaps*, which is a preoccupied name, for the lenticular or oval-sectioned teeth, with *L. aquilungius* of New Jersey as type. Marsh substituted *Dryptosaurus* for the preoccupied name *Lælaps* and added a couple more species of "*Aublysodon*" in 1892. Hay in 1899 pointed out that Cope had restricted the name *Deinodon* to the U-shaped teeth before Leidy gave the name *Aublysodon* to these teeth. *Aublysodon* therefore, cannot be applied to these teeth. Since it now appears that both types of teeth belonged to one animal, this all becomes unimportant and needs no further discussion.

The original idea of Leidy was that the U-shaped teeth were in the front of the jaw. Cope, however, believed that the lower jaw of his *L. aquilunguis* did not have that kind of teeth in front, hence the conclusion, shared by Leidy and Marsh, that the U-shaped teeth were a distinct type. When Marsh secured complete skulls of megalosaurians from the Morrison, it was evident that the upper front teeth approached this type to some degree, but they are by no means so sharply contrasted in size and form with the maxillary and dentary teeth as are the teeth of *Deinodon*. Marsh as late as 1892 regarded them as distinct.

Skulls from the Edmonton of Canada were described by Cope in 1892 and subsequently more fully described by Lambe in 1904, but these still failed to show the characters of the premaxillary teeth. In 1905 Osborn described the gigantic *Tyrannosaurus* and "*Dynamosaurus*" of the Lance and distinguished them primarily by large humerus ascribed to the one and dermal plates to the other.[1] Osborn in this paper excludes from "*Deinodon*" the small U-shaped teeth figured by Leidy, but recognizes the large U-shaped teeth as "premaxillary and premandibular." Lambe in describing *Gorgosaurus* follows Osborn in this restriction and distinguishes *Gorgosaurus* from *Deinodon* by the posses-

[1]Both these distinctions were then as now believed to be erroneous by Matthew, as may be seen in his restoration of the skeleton published by Osborn (Fig. 1, *loc. cit.*) and the first has since been definitely abandoned and *Dynamosaurus* recognized as a synonym of *Tyrannosaurus*.

sion in the premaxilla of just such teeth as are thus excluded from the type of *Deinodon!* The fact is, of course, that the "*Gorgosaurus*" skulls from the Red Deer River show that the large U-shaped teeth are anterior dentary, the small U-shaped teeth premaxillary, and the oval and compressed teeth posterior maxillary and mandibular teeth of the same genus, just as Leidy provisionally regarded them in his original description of *Deinodon*.

There is, therefore, nothing in the dentition to separate *Gorgosaurus* from *Deinodon* and they are unquestionably nearly related and, so far as the teeth are concerned, would appear to be the same genus. But, pending the discovery of adequate topotypes from the Judith River beds, the identity has not been finally and conclusively proven. There may be differences in the skull. Certainly, in comparison with the very distinct generic differences that separate both from *Tyrannosaurus*, they fall very clearly into the same group.

Marsh's name *Dryptosaurus* may in an equally provisional way be retained for the New Jersey Cretaceous *D. aquilunguis*. *Lælaps* must be abandoned as a preoccupied name, *Aublysodon* as a synonym of *Deinodon*.

Osborn has already (1917) called attention to another fragmentary type, *Manospondylus gigas*, as possibly identical with *Tyrannosaurus* but based upon an inadequate type. It may further be noted that Marsh described the feet of *Tyrannosaurus* and its allies, referring them to *Ornithomimus* under the name of *O. grandis*. The type of this species is from the Judith, and is probably correctly referred by Gilmore (1920, p. 122) to *Deinodon*. Referred specimens from the Lance are more probably *Tyrannosaurus*, as referred by Gilmore (*loc. cit.*).

Cope referred to "*Lælaps*" and "*Aublysodon*" a number of quite small species known only from isolated teeth, some of which probably belong to the genus here described.

VI.—A New Genus of Carnivorous Dinosaurs from the Cretaceous of Alberta

Dromæosaurus albertensis, new genus, new species

Type.—A. M. No. 5356, skull and lower jaws, and a few foot bones.

Horizon and Locality.—Belly River formation, Red Deer River, Alberta. Found by Barnum Brown, Amer. Mus. Exped., 1914.

Generic Diagnosis.—

Comparable in size with *Ornithomimus*. Dental formula $\frac{\text{Pmx. ? 3; Max. 9}}{\text{Den. 10}}$

Teeth well developed, asymmetrically oval or compressed, sharp-pointed, recurved, serrate on anterior and posterior border. Premaxillary teeth three or more, not reduced in size, strongly convex antero-externally but not of fully U-shaped section. Posterior teeth similar but more compressed and blade-like in both upper and lower jaw, the last maxillary tooth small. Jaws elongate, not massive. Orbital fenestra larger proportionately than in *Deinodon*, not so large as in *Struthiomimus*. Lateral temporal fenestra of good size, much as in *Deinodon*, not reduced as in *Struthiomimus*. Preorbital fenestræ at present known only inferiorly, but evidently large. Frontals comparatively long and wide, the nasals overlapping them considerably, especially at the median line. The prefrontal and postfrontal sutures continuous, not separated by an orbital notch. Maxillo-premaxillary suture nearly vertical, the premaxilla large.

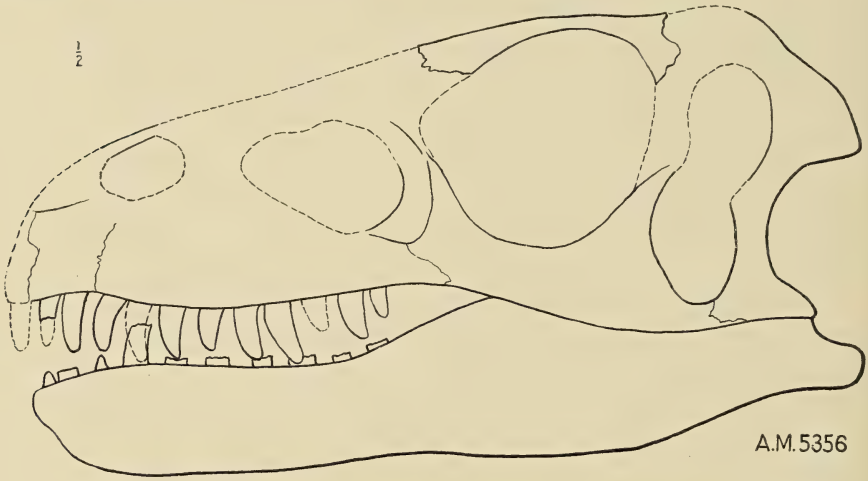

Fig. 1. Type skull of *Dromæosaurus albertensis*, one-half natural size.

The top of the skull is fragmentary and the specimen is at present only partly prepared, so that the above diagnosis will be completed and perhaps modified in some details in a later article. The skull is most like that of *Deinodon* in general proportions, but from a third to a fourth as large lineally, and but little larger than that of *Struthiomimus altus*. It differs from *Deinodon* in the reduced number of teeth, the large premaxillary teeth and the unsymmetric form of the maxillary teeth as well as in the light skull construction, large fenestræ and numerous details that might be largely associated with its small size.

The foot bones are very different from those of either *Deinodon* or *Struthiomimus*, but so fragmentary that they are not positively identifiable, and no generic characters can be based upon them.

The distal half of a metapodial, slightly larger than the mc. II of *Struthiomimus* and only a little smaller than mc. II of *Deinodon* (despite the enormous difference in size of the skeleton) has a deeply grooved ginglymoid distal facet, as in *Deinodon*, but shows a very distinct lateral appression surface. In *Struthiomimus* there is an appression surface on mc. II, but the distal end of the bone is wholly different with a con-

vex condylar facet; it also is of about the same size. Another much smaller metapodial has a less distinctly grooved distal facet and more irregular shaft that may be incomplete proximally. Of the phalanges there are three that fit so closely that they appear to belong with the metapodial first mentioned, but if so it must be the fourth digit, not the second, and may belong to the pes instead of the manus. A fourth phalanx is of similar type but distinct in details from any of the first three. A fifth is a proximal phalanx of size more suited to the smaller metapodial above mentioned, but does not fit it; it is rather short with concave basined head and laterally compressed distal end, apparently a phalanx of the first digit. A sixth phalanx is much larger than the others but only the distal end is preserved, its facet deeply grooved and very similar to the distal facet of the metapodial first noted. Possibly, but not probably, this is a median metapodial.

The comparison of these bones with the complete manus and pes of *Struthiomimus* and of *Deinodon* shows clearly that *Dromæosaurus* differs greatly in the construction of manus or pes, or both, from either of these genera and suggests a less degree of specialization and reduction of the digits in manus or pes.

Although provisionally referred to the family Deinodontidæ, the differences in the skull, number of teeth, and form of premaxillary teeth, together with the apparent diversity in construction of the foot bones, warrant placing *Dromæosaurus* in a distinct subfamily Dromæosaurinæ.

56.4,530

Article VII.—PHYLOGENY OF THE AMMONITE GENUS *OCHETOCERAS*[1]

By Marjorie O'Connell

INTRODUCTION

The family of the Harpoceratidæ includes the closely involute, discoidal ammonites which possess a smooth, noded, or crenulated keel, sigmoidal costæ and sometimes, but not always, a lateral groove or channel. The sides of the aperture have a sigmoidal curve parallel to the costæ or they are prolonged into lateral lappets, while the venter is produced into a rounded crest. The sutures are simple, with narrow digitate lobes and squarish saddles, the latter usually radial. The family ranges from the Lower Jurassic (Liassic) into the Lower Cretaceous (Comanchic).

In this family two sub-families have been recognized, the Harpoceratinæ of Zittel, including such typical forms as *Harpoceras* Waagen, *Lioceras* Hyatt and *Brasilia* Buckman, and the Oppelinæ[2] of Haug, including as representative genera *Oppelia* Waagen, *Oechotraustes* Waagen, *Streblites* Hyatt and *Creniceras* Munier-Chalmas.

Prior to the year 1885 the large group of discoidal forms possessing a lateral groove or canal, and called, therefore, the "canaliculati," had generally been assigned to the genus *Harpoceras* in the first of the two sub-families mentioned above. But in 1885 Haug in his monograph on *Harpoceras* made the suggestion that the "canaliculati" did not belong to that genus nor were they even directly derived from it, but were instead offshoots from *Oppelia*, itself a derivative from *Harpoceras*. It was, therefore, to be classed in the second sub-family, that of the Oppelinæ. He regarded *Ammonites flexuosus canaliculatus* Quenstedt (1849, 'Die Cephalopoden,' Pl. IX, fig. 5; 1858, 'Der Jura,' Pl. LXX, fig. 13), from the upper division (Oxfordian) of the Middle Jurassic beds of Germany, as the connecting link between the oldest Middle Jurassic Oppelias of the "flexuosi" group, that is, the forms with flexed or sigmoidal costæ, and the Upper Jurassic "canaliculati." For this latter group he proposed the sub-generic name *Ochetoceras*[3] (Haug, 1885, p.

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[1]In working up the Jurassic fauna of Cuba collected by Mr. Barnum Brown in 1918 and 1919 it was found necessary to make a comparative study of the European, Cuban, and Mexican species of *Ochetoceras*. The present paper embodies the chief results of that study and includes brief descriptions of several new species from Cuba. The complete descriptions and illustrations will appear in a forthcoming paper on the Jurassic of Cuba.

[2]The species in this subfamily were classified on a phyletic basis by Douvillé (1913).

[3]Derivation: ὀχετός, canal, + κέρας, horn.

698); subsequent refinements in classification have shown that the name should be accorded full generic rank.

The distinguishing generic characteristic of *Ochetoceras*, as pointed out by Haug, is the sharp and angular keel which persists throughout all growth stages even to the end of the conch. This is the primary difference between *Ochetoceras* and *Oppelia*, for in the latter the keel is rounded at least on the body chamber and often throughout the entire conch. A lateral canal is sometimes present in *Oppelia;* in *Ochetoceras* it is typically present throughout the ontogeny although in some species its position is indicated by the flexing of the costæ rather than by an actual groove. Haug accepted as a satisfactory description of his new genus the characterization previously given by Zittel for the "canaliculati," namely (Zittel, 1881–'85, p. 460):

> Rather involute forms with sharpened and keeled venter and high (i.e. laterally compressed) oral aperture. Costæ falciform, strong, with the position of flexing marked by a lateral canal. Suture line very finely incised.

Geologically, *Ochetoceras* has a limited range, having been found so far mainly in the two lower divisions of the Upper Jurassic, the Lusitanian and Kimmeridgian, in each zone from the lowest part of the former (zone of *Peltoceras transversarium*) to the highest part of the latter (zone of *Aulacostephanus pseudomutabilis*), although one species ranges into the lower Tithonian (Portlandian), zone of *Oppelia lithographica*.

Geographically, it has a broad range, occurring in the Old World in England, France, Germany, Switzerland, Portugal, Spain, northern Africa, Persia, the Caucasus Mountains, and the Balkans. In the New World it has previously been known only from Mexico (Durango and Mazapil) until the new discoveries in Cuba showed it to be well represented there.

Since the genus has a limited geological and wide geographical range, it has the ideal requisites for an index fossil for the lower and middle divisions of the Upper Jurassic. Furthermore, the individual species, while having a broad geographical range, have a geological range usually limited to a single faunal zone, so that they serve excellently for the broad correlation of small stratigraphical units in widely separated regions. The succession of biozones[1] which can be recognized for the species of

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[1]A faunal zone, according to Oppel and his followers, is one of the smallest divisions of a formation determined by the presence in it of a particular unit fauna; it is a stratigraphic division defined in terms of the palæontological content. A biozone, as defined by Buckman, is "the range of organisms in time indicated by their entombment in the strata" (Geol. Mag., 1902, p. 556). The current usage of these and other chronological and stratigraphical terms is fully discussed in a paper by C. Diener, 1918, 'Die Bedeutung der Zonengliederung für die Frage der Zeitmessung in der Erdgeschichte,' Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage Band XLII, pp. 65–172.

Ochetoceras is the same in Europe and Cuba, while the strata containing the organic remains in the latter region can be divided into the same faunal zones as those established by Oppel for the Upper Jurassic of western Europe. Thus the phylogeny of *Ochetoceras* has a biological as well as a stratigraphical interest and value.

Haug divided the European species of *Ochetoceras* into the groups of *O. hispidum* and *O. canaliculatum* (Haug, 1885, p. 696). The same two groups may be recognized in Cuba and Mexico where the phyletic series contain some of the same species as occur in Europe. However, not all of the European species have been found in Cuba while, on the other hand, some species have been found in the New World which are unknown in the Old. In general, it may be said that in the Lusitanian the species are cosmopolitan and show a wide geographic range, while in the Kimmeridgian they are provincial. Thus, in the Lusitanian the same species are found in Europe, Asia, and America; in the Kimmeridgian the geographical range is more restricted and the species in various countries, though related, are different. The differences arise from specializations along certain lines such as the trend of one or more conch ratios, the triple carinations on the venter, or the distribution and arrangement of the costæ. But such specializations are not to be regarded as due to the introduction of new characters; they are rather the result of retardation or acceleration of characters already impressed upon the species in the several phyletic lines in the Lusitanian; during the Kimmeridgian the orthogenetic trends which were foreshadowed in the Lusitanian are followed out in a manner which could be predicted from a study of the ontogeny of the species in the older horizon.

DISCUSSION OF SPECIES OF DOUBTFUL AFFINITIES

Before passing to the discussion of the two main groups of *Ochetoceras* recognized by Haug and a third group which is here recognized for the first time, it may be well to note that these three groups do not contain all of the known species of the genus.[1] There are certain European forms of doubtful affinities about which too little is known for their phyletic relations to be determined unless one had access to the types, since the original descriptions and illustrations are poor or incomplete and there is too little information about the ontogeny. For instance, there is *Ammonites guembeli* Oppel (1862, p. 159; 1863, p. 197, Pl. LI, figs. 5*a-c*, 6*a*, *b*, 7*a-c*; also Quenstedt, 1885, p. 842, Pl. XCII, figs. 16, 17)

[1]Douvillé (1913) united all of the species of these three groups into the large phyletic series of *Ochetoceras* without separating out the different branches.

from the lower Kimmeridgian of Bavaria. At a very early stage the conch has nodes on the ventro-lateral angulation, while there is no median keel or lateral groove. It does not, therefore, possess the essential characters of *Ochetoceras*. At a diameter of 30 mm., however, the nodes become elongate in a radial direction and fuse into single costæ which, although of entirely different origin, appear like those of *O. canaliculatum;* instead of the lateral groove characteristic of *Ochetoceras* there is a row of fine nodes along the middle of the lateral zone. The conch proportions of *A. guembeli* at this stage are also like those of *O. canaliculatum;* thus, at a diameter of 30 mm., the height of the whorl is 15 mm., the width 7 mm., and width of umbilicus is 3–4 mm., giving the ratios of height to diameter 0.50, width to diameter 0.23, width to height 0.46, width of umbilicus to diameter 0.10 to 0.13. These ratios are almost identical with those for *O. canaliculatum* at a diameter of 90 mm. (see Table 3). After this stage the conch develops a wavy keel resembling a cock's comb. This species was used by Quenstedt as the genoholotype of *Cymaceras* (1885, p. 842), but Haug has placed it in the genus *Ochetoceras* (1885, p. 698; 1908–'11, p. 1049). However, I believe that the latter assignment is not borne out by the facts of the ontogeny, for in the earliest observable stage *A. guembeli* is not an *Ochetoceras*. If, at one stage in its development, it passes through a phase where it has an external resemblance to one of the species of *Ochetoceras* without, however, having evolved its characters in the same way as that species does, and then later develops a keel altogether at variance with the keels of all the other species of *Ochetoceras*, then *A. guembeli* is scarcely to be regarded as genetically related to *Ochetoceras*.

The same may be said for *Harpoceras* (?) *argonautoides* Mayer, var. *sulculufera* Fontannes, from the Tenuilobatus beds of Crussol, Ardèche, France, (Dumortier and Fontannes, 1875, p. 232, Pl. v, fig. 5 and Fontannes, 1879, p. 15), which is related to *A. guembeli* Oppel. There is a third aberrant species, *Ochetoceras* (?) *daghestanicum* Neumayr (Neumayr and Uhlig, 1892, p. 45, Pl. vi, fig. 1) which appears to belong in this same group, although it does not show a wavy or undulatory keel. It occurs in the Lusitanian of the Caucasus, probably in the zone of *Peltoceras bicristatum*, and is distinguished by its smooth inner flanks and its row of nodes in the position of the lateral groove in *Ochetoceras, sensu stricto*. These nodes give rise to bundles of costæ which pass ventrad. It seems not improbable that this form might have given rise to *Cymaceras guembeli* in the Kimmeridgian, for the young of that species resemble the later stages of *O.* (?) *daghestanicum*. Another specialization

from the same Lusitanian form might have given rise to *Harpoceras* (?) *argonautoides sulculufera*, also from the Kimmeridgian, but such suggestions for a phyletic series must be speculative because so little is known about the forms. However, I would not include any of these three species under *Ochetoceras, sensu stricto.*

An isolated form of doubtful affinities which does not seem to fall into any of the phyletic series is *Ochetoceras subclausum* (Oppel) (1863, p. 190, Pl. LII, figs. 3*a*, *b*). It is a small, low-whorled, smooth form occurring in the lower Lusitanian (zone of *Peltoceras transversarium*) of Switzerland and southern Germany. It has a deep lateral groove which is most pronounced at the end of the conch. On the inner whorls there is a sharp median keel, but from the middle of the body chamber to the aperture this angulation decreases and the venter becomes rounded as in *Oppelia*. The diameter of a mature conch is 32 mm., height of whorl 13 mm., width of whorl 7 mm. and width of umbilicus 7 mm., giving as conch ratios $\frac{\text{h.i.}}{\text{d}} = .40, \frac{\text{w}}{\text{d}} = .22, \frac{\text{w}}{\text{h.i.}} = .55, \frac{\text{u}}{\text{d}} = .22$. The last whorl is loosely coiled and slants off across the preceding with the result not only that the umbilicus is increased in width but also that the spiral curve of the venter is distorted. The partial loss of the power of coiling and the loss of the keel are generally signs of onto- or phylo-gerontism, and such appears to be the case in the present instance, for *O. subclausum* was evidently a decadent species and it left no known descendants.

The upper Tithonian *Ammonites folgaricus* Oppel and the Lower Cretaceous (Valanginian) *Ammonites macrotelus* Oppel have been assigned to *Ochetoceras* by Douvillé (1913, p. 63), but they do not belong to that genus in the restricted sense.

GROUP OF *OCHETOCERAS AROLICUM*

General Characteristics.—This is a small, heterogeneous assemblage of species of doubtful affinities. It includes forms with nearly smooth conchs, on which costæ developed during the ephebic or gerontic stage. There is no lateral groove but its position is indicated either by the locus of the inner ends of short costæ on the outer flanks or by the locus of the angle of flexing of long costæ which pass from umbilicus to venter. Keel triple, with carinations of equal height or with median keel elevated. Nearly all of the species show gerontic tendencies.

TABLE 1. DIMENSIONS, PROPORTIONS AND GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF THE SPECIES IN THE GROUP OF *Ochetoceras arolicum* (Oppel)

Geological Age	Faunal Zone	Species	Geographical Distribution	d[2] mm.	h. i. mm.	h. i. / d	w mm.	w / d	w / h. i.	u mm.	u / d
1	2	3	4	5	6	7	8	9	10	11	12
Portlandian	Zone of *Oppelia lithographica*	*O. steraspis* (Oppel) (Cotypes)	Germany: Solnhofen, and Eichstädt, Bavaria; Württemberg	85	50	.58	17[1]	20[1]	.34[1]	9	10
Kimmeridgian	Zone of *Aulacostephanus pseudomutabilis*		Switzerland: Canton Aargau								
Kimmeridgian	Zone of *Streblites tenuilobatus*										
Lusitanian	Zone of *Peltoceras bicristatum*	*O. trimarginatum* (Oppel) (Cotypes)	Germany: Bavaria and Württemberg	51[1]	30.6[1]	.60[1]	11[1]	.22[1]	.36[1]	13[1]	.25[1]
Lusitanian	Zone of *Peltoceras transversarium*	*O. arolicum* (Oppel) (Cotypes)	Switzerland: Canton Aargau Germany: Baden, Württemberg and Bavaria	74	40	.54	16	.21	.40	9	.12
Lusitanian	Zone of *Peltoceras transversarium*	*O. stenorhynchum* (Oppel) (Cotypes)	Switzerland: Canton Aargau Germany: Baden, Swabian Alp, Württemberg	40	20	.47	8	.18	.40	7	.16

[1]Approximate.
[2]Meaning of abbreviations: d = diameter; h.i. = height of whorl from line of involution to venter; w = width of whorl; u = width of umbilicus.

Lower Lusitanian, Zone of *Peltoceras transversarium*

Ochetoceras arolicum (Oppel)

Specific Characters.[1]—Conch flat, discoidal, involute, with convergent lateral zones and sagittate cross-section; triple keel; in ephebic stage, faint, widely-spaced, crescentic folds on ventral half of each lateral zone. (Oppel, 1863, p. 188, Pl. li, figs. 1*a*, *b*, 2*a*, *b*).

Geographical Distribution.—Birmensdorf, near Baden, Canton Aargau, Switzerland.

Ochetoceras stenorhynchum (Oppel)

Specific Characters.[1]—Conch strongly compressed, whorls smooth up to body chamber where faint costæ appear. Umbilicus broad with sloping sides and blunt umbilical shoulder. Venter moderately wide with three carinations of equal height. Involution decreases in gerontic stage. Body chamber occupies three-fifths of a whorl. Suture like that of *O. trimarginatum* (see below), (Oppel, 1863, p. 189, Pl. lii, figs. 1*a*, *b*).

Geographical Distribution.—Lägern, near Baden, Canton Aargau, Switzerland.

The Relation of the Species from the Lower Lusitanian

These two species are almost intermediate in generic characters between *Oppelia* and *Ochetoceras;* they have the form, general appearance, and some of the surface features of the latter genus but they do not possess the lateral groove, although its position is indicated by the ends of the costæ. The narrow venter (even in *O. stenorhynchum* it is not very wide) and the triple carinations persisting to the end of the conch indicate that these two species belong to *Ochetoceras* rather than to *Oppelia.* Both species appear to be offshoots from *Oppelia eucharis* (D'Orbigny) (1842, p. 524, Pl. cxcviii, figs. 3, 4) which occurs in the upper Oxfordian in eastern and western France; *Ochetoceras arolicum* represents a specialization in extreme sharpening of the venter with the development of triple carinations of which the middle is the highest, while *Ochetoceras stenorhynchum* specialized towards a broader triple venter with all three carinations of equal height. *Oppelia eucharis* at a diameter of 60 mm. has the following ratios: $\frac{\text{h.i.}}{\text{d}} = .54$, $\frac{\text{w}}{\text{d}} = .20$, $\frac{\text{w}}{\text{h.i.}} = .37$, $\frac{\text{u}}{\text{d}} = .13$.

Upper Lusitanian, Zone of *Peltoceras bicristatum*

Ochetoceras trimarginatum (Oppel)

Specific Characters.—Conch compressed; whorls smooth, except last one on which are 20 weak costæ. Umbilicus very broad, tapering outward near aperture. Suture with five short lateral lobes and saddles; first lateral lobe palmate and longer

[1]The dimensions and conch ratios are given in Table 1, p. 392.

than ventral; first lateral saddle broad and asymmetrically divided into two parts. Venter with three carinations of same height. Cross-section sagittate with lateral zones convergent. (Oppel, 1862, p. 159, Pl. L, figs. 2*a*, *b*.)

Geographical Distribution.—Bavaria and Württemberg, Germany.

The Relations of *O. trimarginatum* to Other Species

Ochetoceras trimarginatum was derived from *O. stenorhynchum* with which it agrees in sutures and type of keel. The rather great divergence in conch ratios between the two species is to be explained by the evidences of phylo-gerontism even in the older one. In both species there is a loss of the power of coiling, which produces an increasingly wider umbilicus, whereas in normal series the involution increases with the age of the individual. This particular sign of gerontism is observable in all individuals of each species, so that it is an evidence of onto-gerontism, and it also obtains in successive species, so that is indicative of phylo-gerontism. In *O. trimarginatum* the umbilicus is one-fourth the diameter in width, being thus considerably broader than in any other species in any series. The *stenorhynchum-trimarginatum* branch was evidently decadent; it was confined to the Lusitanian, having no known descendants, and the geographical distribution was restricted to the regions of the Swiss and Swabian Jura.

Upper Kimmeridgian, Zone of *Aulacostephanus pseudomutabilis*, and Lower Tithonian (Portlandian), Zone of *Oppelia lithographica*

Ochetoceras steraspis (Oppel)

Specific Characters.—Whorls compressed, high and thin. Umbilicus narrow. Conch smooth until half grown; in later stages covered with numerous thin costæ which, on inner part of flanks, are very faint and are directed obliquely orad either in a straight line or in a sigmoidal curve and, on outer part of flanks, have a falciform curvature; at the middle of the lateral zones the costæ are flexed at a sharp angle. In early stages venter tricarinate, in later stages unicarinate. (Oppel, 1863, p. 251, Pl. LXIX, figs. 1–9.)

Geographical Distribution.—Solnhofen and Eichstädt, Bavaria, and Württemberg, Germany; Lägern, near Baden, Canton Aargau, Switzerland.

The Relation of *O. steraspis* to Other Species

The young of *O. steraspis* is smooth and in all respects like *O. arolicum* at a diameter of 40 mm. (see Oppel, 1863, Pl. LXIX, figs. 3*a*, *b*, and compare with Pl. LI, figs. 1*a*, *b*). In the adult *O. arolicum* a few widely spaced costæ appear; by acceleration their time of appearance is

TABLE 2. DIMENSIONS, PROPORTIONS AND GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF THE SPECIES IN THE GROUP OF *Ochetoceras hispidum* (Oppel)

Geological Age	Faunal Zone	Species	Geographical Distribution	d[2] mm.	h. i. mm.	h. i. / d	w mm.	w / d	w / h. i.	u	u / d
1	2	3	4	5	6	7	8	9	10	11	12
Kimmeridgian	Zone of *Streblites tenuilobatus*	*O. hispidiforme* (Fontannes) (Holotype)	France: Crussol, Ardèche	39	19.9[1]	.51	10[1]	.26	.51	7[1]	.18
		O. semimutatum (Fontannes) (Holotype)	France: Crussol, Ardèche	30	16.5[1]	.55	11.1[1]	.37	.67	4.5[1]	.15
Lusitanian	Zone of *Peltoceras bicristatum*										
	Zone of *Peltoceras transversarium*	*O. mexicanum* Burckhardt (Holotype)	Mexico: Cerro del Volcán, Durango	62	35	.56	19	.30	.54	10	.16
		(Plesiotype)	Cuba: Viñales, Pinar del Rio. *	44.7	24.8	.55	14.0	.31	.56	6.5	.14
				41.0	23.2	.56	12.7	.31	.55	6.6	.16
				35.0	19.4	.55	11.8	.33	.60	5.3	.15
		O. pedroanum Burckhardt (Holotype)	Mexico: Cerro del Volcán, Durango	35	18	.51	11.5	.32	.63	6.5	.18
		O. hispidum (Oppel) (Cotypes)	Germany: Bavaria, Württemberg Switzerland: Aargau France: Voirons in Savoie	44	23	.52	16	.36	.69	8	.18

*Bracketted readings are for dimensions at successive stages on the same specimen.
[1]Calculated from the ratios.
[2]For meaning of abbreviations see p. 392.

pushed back in the ontogeny of *O. steraspis* and they have become a more deeply impressed and persistent character. The specialization, in this as in the other end members of the phyletic series of *Ochetoceras*, is the trend toward multiple costæ.

GROUP OF *OCHETOCERAS HISPIDUM*

General Characteristics.—This is a small group comprising forms with broad, inflated whorls, thick, coarse costæ, a broad umbilicus and a noded keel. All of the species have been founded upon incomplete specimens so that the characters of the late ephebic and gerontic stages are unknown. The specific descriptions are for individuals ranging from 30 to 60 mm. in diameter and for conchs of that size the following ratios may be considered as characteristic of the group (see Table 2, p. 395).

The height of the whorls is always slightly over, but never much in excess of one-half the diameter (range 0.51—0.56); the width of the whorls is about one-third the diameter, being, with one exception, 0.30 or over (range 0.26—0.36); the ratio of width to height is over 0.50 (range 0.51—0.69), in most instances over 0.55; the range of the ratio of width of umbilicus to diameter is 0.14 to 0.18. The following trends in proportion are shown in both ontogeny and phylogeny: the relative height remains practically constant so far as can be observed; the relative width as compared both to diameter and to height shows a tendency to decrease, while the relative width of the umbilicus is remarkably constant. These facts indicate that the chief change in proportions which the species of this group undergo is the modification of the relative width of the whorls. This allometric trend is both ontogenetic and phylogenetic. Thus, the whorls are markedly inflated in the early stages of primitive species but they become flatter in the later stages, and similarly in *O. hispidiforme*, the final representative of group, the whorls at a diameter of only 39 mm. are relatively more compressed than they are at a greater diameter in any of the species from an earlier horizon.

The keel is low, denticulated or noded, bounded by smooth concave zones but no true channels, and not markedly triple, although in most species subdued lateral angulations develop between the lateral and ventral zones.

The sutures are known only in the species of the lower Lusitanian; they are simple with shorter lobes and saddles, the latter usually broader, the former narrower, than in the group of *Ochetoceras canaliculatum*.

Lower Lusitanian, Zone of *Peltoceras transversarium*

Ochetoceras hispidum (Oppel)

Specific Characters.[1]—Whorls broad, umbilicus wide. Lateral groove broad and deep, not crossed by costæ. Cross-section of whorls broad oval. On inner flanks, between groove and umbilicus, coarse, straight, evenly-spaced costæ with oblique orad trend; on outer flanks, between groove and venter, costæ nearly straight, slightly curved orad, unbranched, club-shaped with thick end near venter. No intercalated costæ. Keel simple with no lateral carinations; large median nodes, one corresponding to each costa. (Oppel, 1863, p. 193, Pl. lii, figs. 2*a*, *b*.)

Geographical Distribution.—The species occurs in Bavaria, Württemberg, and southern Baden, Germany; in Canton Aargau, Switzerland (Oppel, 1863, p. 193; Quenstedt, 1885, p. 840, Pl. xcii, figs. 9–11), and in Savoie, eastern France, (Favre, 1875, p. 27, Pl. ii, fig. 8). *O. hispidum*, therefore, is confined to the type regions of the European Jurassic, to eastern France, northern Switzerland and southwestern Germany.

Ochetoceras mexicanum Burckhardt

Specific Characters.[1]—Whorls high and moderately broad. Costæ straight, oblique orad on inner flanks, coarse, slightly curved, strong, club-shaped, occasionally branching on outer flanks. Keel finely noded and bounded by shallow lateral channels and subdued lateral carinæ. Suture: five broad lateral saddles, four narrow, elongate, digitate lateral lobes. (Burckhardt, 1912, p. 7, Pl. ii, figs. 8–12; O'Connell, 1920, p. 686, Pl. xxxviii, figs. 1–3.)

Geographical Distribution.—Cerro del Volcán, Durango, Mexico; Viñales, Province of Pinar del Rio, Cuba.

Ochetoceras pedroanum Burckhardt

Specific Characters.[1]—Whorls rather thick and only moderately high. Lateral groove broad, deep and sharply defined. Costæ on outer flanks robust, not branched. Umbilicus broad. Cross-section of whorls elongate oval. Keel finely noded; bounded by low ventro-lateral angulations. Suture: six lateral saddles, six lateral lobes; ventral lobe a little shorter than first superior; lateral saddles asymmetrically divided into two parts. (Burckhardt, 1912, p. 9, Pl. i, figs. 13–17.)

Geographical Distribution.—Cerro del Volcán, Durango, Mexico.

The Relation of the Lower Lusitanian Species

Ochetoceras mexicanum occupies an intermediate position between the species of the *O. hispidum* group and those of the *O. canaliculatum* group, but is undoubtedly a derivative of the former. It is not improbable that *O. mexicanum*, described from a specimen 62 mm. in diameter, represents the adult stage of *O. pedroanum*, described from an incomplete specimen only 35 mm. in diameter. The holotypes of these spe-

[1]Dimensions and conch ratios are given in Table 2, p. 395.

cies came from Mexico. But in Cuba occurs a single specimen of *O. mexicanum* nearly 45 mm. in diameter and the conch proportions and general characters which it shows at a diameter of 35 mm. are nearly identical with those of *O. pedroanum* at that diameter, while as it increases in size it approaches the proportions of the Mexican *O. mexicanum*. The sutures in both species are similar and both have subdued tricarinate noded keels, although the lateral carinations are not very pronounced. *O. pedroanum* itself is so near to *O. hispidum* in all of its characters and proportions as to be regarded as a probable variation of that species, the differences between the two being such as are to be expected in forms widely separated geographically.

Lower Kimmeridgian, Zone of *Streblites tenuilobatus*

Ochetoceras semimutatum (Fontannes)

Specific Characters.[1]—Whorls strongly compressed. Costæ thick and straight on inner flanks, club-shaped, curved and occasionally branched on outer flanks. Keel noded; median carination bounded by faint lateral carinations. (Fontannes, 1879, p. 17, Pl. II, fig. 9.)

Geographical Distribution.—Crussol, Ardèche, France.

Ochetoceras hispidiforme (Fontannes)

Specific Characters.[1]—Whorls relatively low and greatly compressed. Ratio of width to height of whorl only one-half. Umbilicus broad. Costæ coarse, straight and oblique on inner flanks, club-shaped, falciform and bifurcate on outer flanks.

Geographical Distribution.—Crussol, Ardèche, France.

The Phyletic Trends in the *O. hispidum* Group

The most variable conch ratio is that of width to height of whorl. Since the relative height as compared to the diameter remains nearly constant in onto- and phylo-stages, while the relative width decreases, it is evident that the width to height ratio for the whorl is essentially a function of the width. In *O. mexicanum*, in which more onto-stages can be studied than in any other species of the group, the decrease in the width to height ratio is clearly shown. The same decrease appears in the phylogeny, *O. hispidum*, the oldest species, having the highest ratio, *O. semimutatum*, the youngest species, the lowest ratio. Furthermore, the change in ontogeny from a broad to a narrow, strongly compressed whorl takes place more rapidly in later than in earlier species, showing that this change in proportion has been accelerated. Thus, the

[1]Dimensions and conch ratios are given in Table 2, p. 395.

Lusitanian	Zone of *Peltoceras bicristatum*	*O. semifalcatum* (Oppel) (Plesiotype)	Switzerland: Aargau	61.0	31.3	.51	15.8	.26	.50	9.6	.15
			Cuba: Constancia, Pinar del Rio *	47.4	24.7	.52	12.1	.25	.49	7.7	.16
			Cuba: Rio Hondo, Pinar del Rio *	56.0	29.0	.52	14.3	.25	.49	8.2	.14
		(Plesiotype)		42	23.2	.55	11.3	.26	.49	5.3	.13
		(Cotypes) *O. marantianum* (D'Orbigny)	France: Marans in Charante Inférieure, etc. Germany: Swabian Jura, etc. Spain, Portugal, the Balkans	55	27.5[3]	.50	9.9[3]	.18	.36	8.8[3]	.16
		(Plesiotype)	Cuba: Constancia, Pinar del Rio	23.3	11.8	.50	6.7	.29	.57	5.1	.21
	Zone of *Peltoceras transversarium*	(Holotype) *O. canaliculatum* (Buch) var. *burckhardti* O'Connell	Cuba: Viñales and Constancia, Pinar del Rio	55.8	31.5	.56	13.4	.23	.42	7.5	.13
				55.5	31.0	.56	16.0	.29	.51	8.0	.14
			Mexico: Cerro del Volcán, Durango	32.0	18.5	.57	8.0	.25	.43	5.0	.16
		O. canaliculatum (Buch)	Switzerland: Aargau France: Rhone Valley Germany: Württemberg, etc. England, Spain, Portugal, Persia, northern Africa.	90.[2]	52.6	.56	21.6	.23	.43	12.2	.13

*Bracketted readings are for dimensions at successive stages on the same specimen.
[1]Approximate.
[2]Dimensions given by D'Orbigny (1842, p. 525).
[3]Calculated from ratios.
[4]For meaning of abbreviations, see p. 392.

TABLE 3. DIMENSIONS, PROPORTIONS, AND GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF THE SPECIES IN THE GROUP OF *Ochetoceras canaliculatum* (Buch)

Geological Age	Faunal Zone	Species	Geographical Distribution	d[4] mm.	h. i. mm.	h. i. / d	w mm.	w / d	w / h. i.	u mm.	u / d
1	2	3	4	5	6	7	8	9	10	11	12
Kimmeridgian	Zone of *Aulacostephanus pseudomutabilis*	*O. zio* (Oppel) (Holotype)	Germany: Württemberg	41	21	.51	8	.19	.38	6	.14
	Zone of *Streblites tenuilobatus*	*O. neohispanicum* Burckhardt (Holotype)	Mexico: Durango	70	39	.55	16[1]	.22[1]	.41[1]	11	.15
		O. vicente dentatum, new variety (Holotype)	Cuba: Constancia, Pinar del Rio	46	25.8	.56	13.1	.28	.50	5.7	.12
		O. vicente, new species (Holotype and Paratype)	Cuba: San Vicente, Pinar del Rio *	69.2 42.9 36.5	37.3 23.8 19.3	.54 .53 .53	20.4 12.6 10.4	.29 .29 .29	.55 .53 .54	9.5 6.6 5.7	.13 .15 .16
		O. canaliferum (Oppel) (Holotype)	Germany: Wurttemberg Switzerland: Aargau France: Crussol, Ardèche	76	43	.56	15	.19	.34	9	.11
		O. palissyanum (Fontannes) (Cotypes)	France: Crussol, Ardèche	54 46	28.6[3] 23[3]	.53 .50	9.7 10[3]	.18[2] .22	.34 .44	8.1[3] 8.2[3]	.15 .18
Lusitanian	Zone of *Peltoceras bicristatum*	(Cotypes)	Germany: Württemberg and Bavaria Switzerland: Aargau	61.0	31.0	.51	16.0	.26	.51	9.0	.15
		O. semifalcatum (Oppel) (Plesiotype)	Cuba: Constancia, Pinar del Rio *	61.0 47.4	31.3 24.7	.51 .52	15.8 12.1	.26 .25	.50 .49	9.6 7.7	.15 .16
		(Plesiotype)	Cuba: Rio Hondo, Pinar del Rio *	56.0 42	29.0 23.2	.52 .55	14.3 11.3	.25 .26	.49 .49	8.2 5.3	.14 .13
		(Cotypes)	France: Marans in Charante Inférieure, etc. Germany: Swabian Jura, etc. Spain, Portugal, the Balkans	55	27.5[3]	.50	9.9[3]	.18	.36	8.8[3]	.16
		O. marantianum (D'Orbigny) (Plesiotype)	Cuba: Constancia, Pinar del Rio	23.3	11.8	.50	6.7	.29	.57	5.1	.21
	Zone of *Peltoceras transversarium*	(Holotype)	Cuba: Viñales and Constancia, Pinar del Rio	55.8 55.5	31.5 31.0	.56 .56	13.4 16.0	.23 .29	.42 .51	7.5 8.0	.13 .14
		O. canaliculatum (Buch) var. *burckhardti* O'Connell	Mexico: Cerro del Volcán, Durango	32.0	18.5	.57	8.0	.25	.43	5.0	.16
		O. canaliculatum (Buch)	Switzerland: Aargau France: Rhone Valley Germany: Württemberg, etc. England, Spain, Portugal, Persia, northern Africa.	90.[2]	52.6	.56	21.6	.23	.43	12.2	.13

*Bracketted readings are for dimensions at successive stages on the same specimen.
[1]Approximate.
[2]Dimensions given by D'Orbigny (1842, p. 525).
[3]Calculated from ratios.
[4]For meaning of abbreviations, see p. 392.

TABLE 3. DIMENSIONS, PROPORTIONS, AND GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF THE SPECIES IN THE GROUP OF *Ochetoceras canaliculatum* (Buch)

Geological Age	Faunal Zone	Species	Geographical Distribution	d[4] mm.	h. i. mm.	h. i. / d	w mm.	w / d	w / h. i.	u mm.	u / d
1	2	3	4	5	6	7	8	9	10	11	12
Kimmeridgian	Zone of *Aulacostephanus pseudomutabilis*	*O. zio* (Oppel) (Holotype)	Germany: Württemberg	41	21	.51	8	.19	.38	6	.14
	Zone of *Streblites tenuilobatus*	*O. neohispanicum* Burckhardt (Holotype)	Mexico: Durango	70	39	.55	16[1]	.22[1]	.41[1]	11	.15
		O. vicente dentatum, new variety (Holotype)	Cuba: Constancia, Pinar del Rio	46	25.8	.56	13.1	.28	.50	5.7	.12
		O. vicente, new species (Holotype and Paratype)	Cuba: San Vicente, Pinar del Rio *	69.2 42.9 36.5	37.3 23.8 19.3	.54 .53 .53	20.4 12.6 10.4	.29 .29 .29	.55 .53 .54	9.5 6.6 5.7	.13 .15 .16
		O. canaliferum (Oppel) (Holotype)	Germany: Wurttemberg Switzerland: Aargau France: Crussol, Ardèche	76	43	.56	15	.19	.34	9	.11
		O. palissyanum (Fontannes) (Cotypes)	France: Crussol, Ardèche	54 46	28.6[3] 23[3]	.53 .50	9.7 10[3]	.18? .22	.34 .44	8.1[3] 8.2[3]	.15 .18
		(Cotypes)	Germany: Württemberg and Bavaria	61.0	31.0	.51	16.0	.26	.51	9.0	.15

lower Lusitanian *O. mexicanum* has a height to width ratio of .30 at a diameter of 62 mm., but the lower Kimmeridgian *O. hispidiforme* has attained a corresponding ratio of 0.26 at a diameter of only 39 mm., which indicates that it probably had the same ratio as *O. mexicanum* when it was only about half the size of that species.

In respect to the type of costæ and mode of branching the trend is toward an increase in the number of costæ with a concomitant decrease in coarseness and a bifurcation of the ventral ends. The costal trends in this phyletic series are parallel to those which are observed in the *O. canaliculatum* group (see below, p. 409). For example, *O. hispidiforme* bears the same relation to *O. hispidum* as *O. marantianum* does to *O. canaliculatum*, the development of the analagous costal branching taking longer in the *O. hispidum* than in the *O. canaliculatum* group. (See Table 5.)

GROUP OF *OCHETOCERAS CANALICULATUM*

General Characteristics.—This group includes highly involute species with thin, flat whorls having a cuneate cross-section and flat convergent lateral zones. In general the umbilicus is relatively smaller than in the *O. hispidum* group, ranging from 0.11 to 0.16 (0.12 to 0.15 most characteristic), while in the *hispidum* group the range is from 0.12 to 0.18, with 0.16 to 0.18 as most characteristic. The most distinctive conch ratio for the group is that of width to height, which is seldom as great as one-half and may be as small as one-third, with a maximum range of 0.34 to 0.57 and a characteristic range for adult forms of 0.36 to 0.49. Height of whorls slightly over one-half the diameter, with a range of 0.50 to 0.56; whorls narrow, with a ratio range of 0.18 to 0.29. The venter is generally tricarinate; median keel finely noded. Lateral groove narrow, usually not sharply defined, persistent in ontogeny, becoming faint in onto- and phylo-gerontic stages. Costæ on inner flanks widely spaced, oblique orad, straight; on outer flanks numerous, falciform, crowded. In later onto- and phylo-stages costæ branch ventrally and there are fine, short, intercalated costæ. Sutures simple in early, but more complex in later, phylo-stages, where the lobes are long, narrow, and deeply incised, and possess a slender, pointed termination; the saddles are broad and squarish.

Lower Lusitanian, Zone of *Peltoceras transversarium*

Ochetoceras canaliculatum (Buch)

Specific Characters.[1]—Compressed, involute, with flat or slightly convex, convergent lateral zones. In the adult, height of whorl a little over one-half, width

[1]Dimensions and conch ratios given in Table 3.

one-quarter, of the diameter; ratio of width to height less than one-half (0.43). Lateral groove dorsad of median lateral line; shallow, but persistent. On inner flanks faint folds, few in number; on outer flanks, sickle-shaped, unbranched costæ, concave orad, not continuous with folds on inner flanks. Costæ impersistent in ontogeny, conch smooth before and after costate stage. Triple keel throughout ontogeny. (Buch 1831, Pl. I, figs. 6–8; D'Orbigny, 1842, Pl. CXCIX, figs. 1, 2; Oppel, 1862, Pl. LI, fig. 3; O'Connell, 1920, pp. 681–682.)

GEOGRAPHICAL DISTRIBUTION.—Western, central and southern Europe, eastern Asia, northern France.

Ochetoceras canaliculatum burckhardti O'Connell

VARIETAL CHARACTERS.—Conch compressed, discoidal. Whorls increase rapidly; umbilicus small, deep, with vertical walls. Cross-section cuneate, slightly bulging, two and one-half times as high as wide; height decreases with age; greatest width at about middle of whorl. Lateral groove present from earliest observable stage to end of conch, becoming obsolescent before beginning of body chamber; crossed at intervals by folds. Median keel high and angular with flat bounding zones and sharp ventro-lateral angulations; fine nodes present throughout. Indistinct straight folds on inner flanks; few widely-spaced crescentic costæ on outer flanks for one or two volutions of neanic or ephebic stages; conch almost smooth after a diameter of 50 mm. Sutures simple; at least four lateral lobes, short, broad, with palmate terminations; saddles squarish with asymmetric tripartite division. (O'Connell, 1920, p. 686, Pl. XXXVIII, figs. 1–3.)

GEOGRAPHICAL DISTRIBUTION.—Viñales, Laguira and Constancia, Province of Pinar del Rio, Cuba; Cerro del Volcán, Durango, Mexico (*vide Ochetoceras canaliculatum* (D'Orbigny), of Burckhardt, 'Faunes Jurassiques, etc.,' 1912, p. 5, Pl. I, figs. 1–7).

The Relations of the Lower Lusitanian Species

As we have already seen (p. 387 above), Haug regarded *Ammonites flexuosus canaliculatus* Quenstedt from the lowest Oxfordian (zone of *Quenstedticeras lamberti*) as the connecting link between the *flexuosi* Oppelias and the true *Ochetoceras canaliculatum*. The adult of Quenstedt's species has a noded keel and the position of the lateral canal is indicated by the flexing of the costæ, although no actual canal is developed. But another character is present which seems to preclude this species from the direct line of descent of the Canaliculati, namely, the rows of spines on the ventro-lateral angulations. These are not present in the young of any of the Upper Jurassic Canaliculati as they should be in accordance with the law of recapitulation. Quenstedt referred to Buch's illustration of *flexuosus* in which the ventro-lateral nodes are very pronounced (Buch, 1831, Pl. VIII, fig. 3) and his own illustration shows the same feature (Quenstedt, 1858, p. 531, Pl. LXX, fig. 13).

Wepfer in his retroactive revision of the Oppelias (1913, p. 39) rightly called attention to the fact that the costæ in Quenstedt's species thicken ventrally in a way which is not to be expected in a form ancestral

to the Canaliculati and he also pointed out that in the latter the external lobe is nearly as long as the first lateral lobe, while in the Flexuosi there is a marked difference in length between the two, the lateral accessory branch of the external lobe being much shorter than the first lateral lobe. For these reasons Wepfer seeks the ancestor of the Canaliculati not in the Flexuosi but in the form originally described by Quenstedt as *Ammonites canaliculatus fuscus* (1849, Pl. VIII, figs. 7–9), later as *A. fuscus* (1885, p. 634, Pl. LXXV) from the Brown Jura ε. But *A. fuscus* also does not seem to fulfill the theoretical requirements for an ancestral form, since the young of *O. canaliculatum* is not like the adult of *A. fuscus*.

Douvillé has made a better suggestion in deriving *Ochetoceras canaliculatum* from *Oppelia henrici* (D'Orbigny) from the zone of *Cardioceras cordatum* and this in turn from *Oppelia hersilia* (D'Orbigny) from the zone of *Quenstedticeras præcordatum* of the Oxfordian (Douvillé, 1913, p. 62). D'Orbigny gave a brief description of *O. hersilia* (1850, p. 351) but did not figure the form. De Loriol has identified a large series of specimens from the *Creniceras renggeri* beds (=zone of *O. præcordatum*) from the Bernese Jura as *O. hersilia* (1898, p. 11, Pl. I, figs. 7–13) and these forms seem to be clearly ancestral to *O. henrici* from the next higher zone, while the latter with its simple flexed costæ, triple keel and foreshadowed lateral canal, serves admirably as the direct ancestor of *Ochetoceras canaliculatum*. This relation is also brought out by other phyletic facts. The young of *Ochetoceras canaliculatum* is smooth up to a diameter of 10 or more millimeters and in this respect it recapitulates with acceleration the smooth stage which lasts in *Oppelia henrici* up to a diameter of 25 mm. The latter species even in the adult does not develop a true lateral canal and this *henrici* stage is recapitulated very early in *Ochetoceras canaliculatum*.

When the conch proportions of the various species under discussion are considered, it is seen that the adult Oxfordian Oppelias have the proportions found in earlier stages in the Lusitanian and Kimmeridgian species of *Ochetoceras*. (See Table 4.)

The transition from the *Oppelia* into the *Ochetoceras* type took place by the slow development of a lateral canal at the angles of flexing of the costæ, and the change from a narrow cuneate venter into a tricarinate venter. The phyletic trends in conch proportions observable in the Upper Jurassic species of *Ochetoceras* were clearly established in the late Middle Jurassic Oppelias. It is also clear from a comparison of the figures in Tables 2 and 4 that the *hispidum* and *canaliculatum* groups are distinct.

TABLE 4. COMPARISON OF THE ALLOMETRIC PROPORTIONS IN THE MIDDLE JURASSIC OPPELIAS AND THE UPPER JURASSIC CANALICULATE DESCENDANTS

Species	Palæontological Zone	d mm.	h. i. mm.	h. i. / d	w mm.	w / d	w / h. i.	u mm.	u / d
Ochetoceras zio (Oppel)	Zone of *Aulacostephanus pseudomutabilis*	41	21	.51	8	.19	.38	6	.14
Ochetoceras neohispanicum (Burck.)	Zone of *Streblites tenuilobatus*	70	39.0	.55	16.0	.22	.41	11	.15
Ochetoceras canaliculatum burckhardti O'Connell	Zone of *Peltoceras transversarium*	55.8	31.5	.56	13.4	.23	.42	7.5	.13
Oppelia henrici (D'Orb.)	Zone of *Cardioceras cordatum*	90	....	.55	....	.21	.38	....	.14
Oppelia hersilia (D'Orb.)	Zone of *Quenstedticeras præcordatum*	81	....	.54	....	.22	.40	....	.18

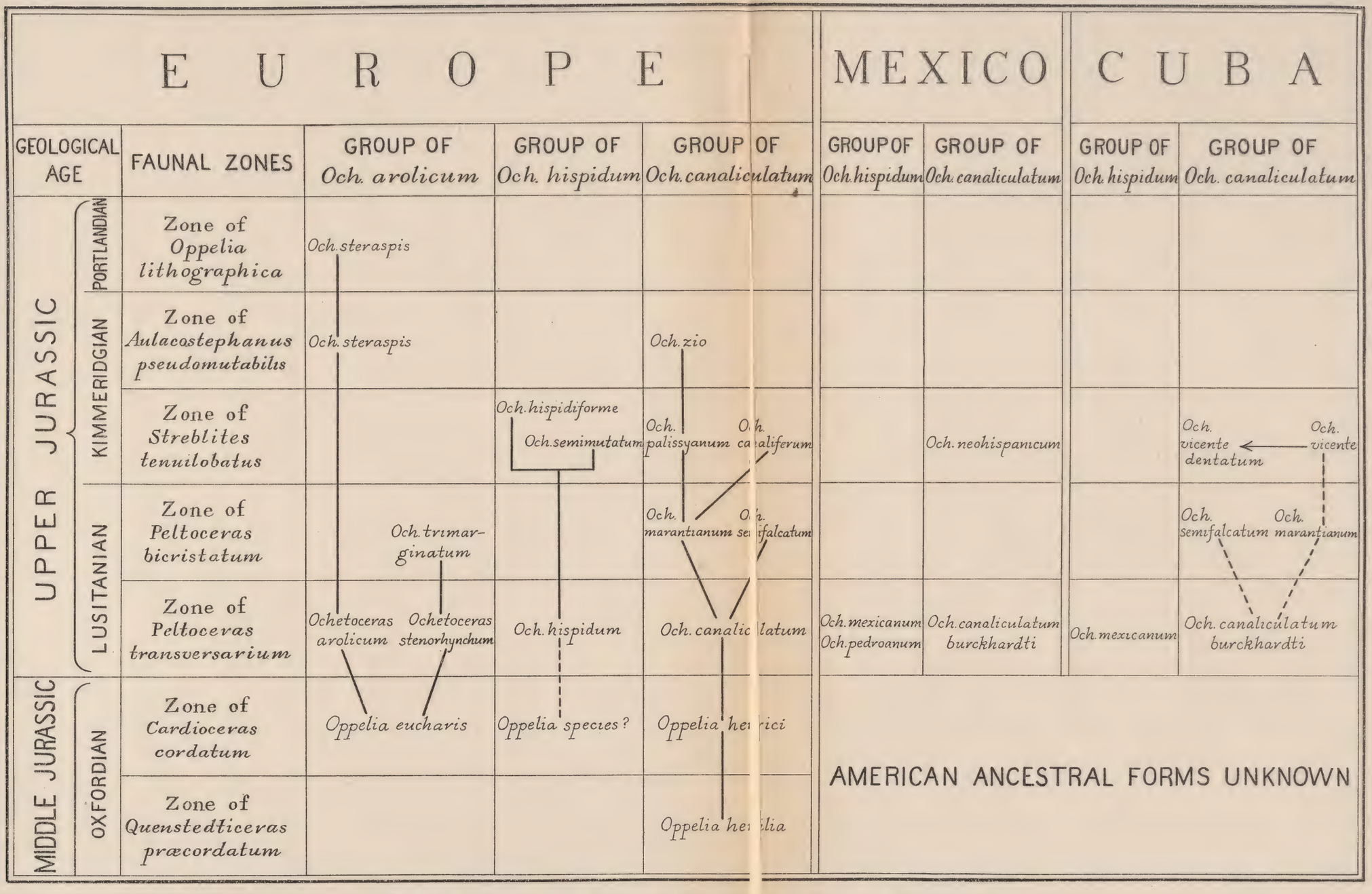

TABLE 5. PHYLOGENY OF EUROPEAN AND AMERICAN SPECIES OF *Ochetoceras*

They are distinguished not only by their different types of surface sculpture but even more especially by their proportions, the species in the *hispidum* group being relatively thicker whorled, having higher ratio of width to diameter and width to height, than those in the *canaliculatum* group. It will be seen (Table 4) that these proportions were established in the ancestors of the latter group in Middle Jurassic time. All of these facts show that Oppel was correct in describing *O. hispidum* and *O. canaliculatum* as distinct species and that Haug's division of the Canaliculati into two major groups derived from these species was essentially sound.

The variety of *canaliculatum* which occurs in Cuba and Mexico is to be regarded simply as a geographical variant of the widespread European form. The Cuban, Mexican and European representatives all show differential acceleration in one or more characters. Thus the suture in the Mexican and European forms is more accelerated than in the Cuban; the number, arrangement and duration of the costæ are the same in the Mexican and Cuban forms, both of which in these respects show acceleration over the European representatives. The American forms are accelerated in respect to the width to height ratio of the whorls, the young in the American variety having the proportions of the older stages of the European species.

Upper Lusitanian, Zone of *Peltoceras bicristatum*

Ochetoceras marantianum (D'Orbigny)

Specific Characters.[1]—Conch strongly compressed; whorls with little convexity, sagittate cross-section. Profound lateral groove. Dorsad of groove a few irregular costæ; ventrad of groove falciform costæ, many of which divide into two branches at one-third their height. Umbilicus straight. Venter narrow, keel sharp. (D'Orbigny, 1842, p. 533, Pl. ccvii, figs. 3–5).

Geographical Distribution.—In Germany (Swabia, Franconia), in Switzerland (Canton Aargau), in France (the Rhone Valley, Haute-Marne, Yonne, the Aquitanian Basin), in Spain (Aragon), in Portugal, and in the Balkans (Dobrudscha), at Constancia, Pinar del Rio, Cuba.

The single specimen of *Ochetoceras marantianum* found in Cuba is of a young individual only 23 mm. in diameter; its proportions are somewhat different from those of D'Orbigny's holotype, as would be expected, but the typical division of the costæ is shown.

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[1]Dimensions and conch ratios given in Table 3.

This species is in the direct line of descent from *O. canaliculatum* showing a specialization toward increased lateral compression and the bifurcation of the costæ. Whether or not the Cuban representative of *O. marantianum* belonged to the European fauna or was independently derived from *O. canaliculatum burckhardti* cannot be determined.

Ochetoceras semifalcatum (Oppel)

Specific Characters.[1]—Conch moderately flat; whorls one-half the diameter in height and one-quarter in width; ratio of width to height one-half. Venter tricarinate; median keel sharp and finely noded. Lateral groove weak; in gerontic stage obsolescent. Dorsad of groove costæ are fine, straight, directed orad; ventrad of groove costæ are bent apicad in a sickle-shaped curve concave orad; are continuous across flanks, but become very weak on dorsal side of groove, while on ventral side they branch near the venter. (Oppel, 1863, p. 194, Pl. LII, figs. 6, 6*a*; Haug, 1885, p. 697.)

Geographical Distribution.—Württemberg, Bavaria, and the Swiss Jura in Europe. Rio Hondo and Constancia, Province of Pinar del Rio, Cuba.

The Cuban material shows nearly all stages of the ontogeny, thus augmenting our knowledge of the species considerably. One specimen is the same size as Oppel's holotype, the measurements of the two varying by less than one millimeter at a diameter of 61 mm. near the end of the body chamber. In the early ephebic stage the conch has almost the same proportions as are exhibited in the late ephebic stage of *O. canaliculatum* (Buch) and of *O. canaliculatum burckhardti* O'Connell (see ratios in Table 3). Not only in actual measurements and proportions does *O. semifalcatum* recapitulate the stages passed through by *O. canaliculatum*, but the mode of development of the keel and costæ is repeated with the result that a young conch of the former species is identical in appearance with a mature conch of the latter. Haug regarded *O. semifalcatum* as a member of the *O. hispidum* group (1885, p. 697), but a study of the ontogeny of the former species, which was not possible with the European material but has been made possible by the discoveries in Cuba, reveals the fact that there is no convergence of characters toward an *O. hispidum* stage. On the contrary, the conch becomes relatively thinner as the ratio of width to height of whorl decreases and the lateral zones are not inflated as in *O. hispidum* but become flatter in the earlier onto-stages, while there is a concomitant decrease, instead of an increase, in the relative width of the umbilicus. These facts are illustrated in a young conch from Rio Hondo (see Table 3): at a diameter of 42 mm. the width of the umbilicus is identical with, and the other ratios

[1]Dimensions and conch ratios given in Table 3.

are very near to, the corresponding ratios in *O. canaliculatum* at a diameter of 90 mm.; every conch ratio of the adult of the older species is recapitulated in the half-grown conch of the geologically younger species. *O. semifalcatum* appears to have been a specialization as a side branch in late Lusitanian time, both in the European and American faunas, but was not in the direct line of descent leading to the Kimmeridgian species. The contemporaneous *O. marantianum* was the one from which the succeeding species were derived. (See Table 4, p. 402.)

Lower Kimmeridgian, Zone of *Streblites tenuilobatus*

Ochetoceras palissyanum (Fontannes)

Specific Characters.[1]—Conch very compressed, discoidal; whorls one-half of the diameter or more in height but less than one-fourth in width; ratio of width to height less than 0.45. Umbilicus shallow and rather broad. Lateral groove broad, shallow, poorly defined. Dorsad of groove costæ are irregularly spaced, of unequal strength, oblique orad, slightly curved; ventrad of groove costæ are numerous; many branch once or twice and they bend sharply orad in approaching the venter. Venter unicarinate, not noded; median keel sharp, passing into lateral zones without interruption by ventro-lateral carinations. (Dumortier and Fontannes, 1875, p. 230, Pl. v, fig. 6, and Fontannes, 1879, p. 18, Pl. II, fig. 10.)

Geographical Distribution.—Crussol, Ardèche, France.

This species was clearly derived from *O. marantianum* by specialization in the direction of multiple branching of the costæ near the ventral margin. In the latter species most, but not all, of the costæ show two branches; in *O. palissyanum* all of the costæ show two or three branches, and there are fine, short intercalated costæ besides. In dimensions and proportions the two species are practically identical.

Ochetoceras canaliferum (Oppel)

Specific Characters.[1]—Whorls high and very narrow. Umbilicus small. Lateral groove narrow, distinct. Dorsad of the groove are a few folds strongly inclined orad and somewhat curved; ventrad there are nine or ten strong, crescentic costæ passing from groove to venter, while between them are large numbers of fine, short costæ—fully 200 on the last whorl—which are strongly bent orad near the venter. Keel sharp, low, may be triple but not so described. (Oppel, 1856, p. 686; 1863, p. 195, Pl. LII, figs. 4*a*, *b*.)

Geographical Distribution.—Württemberg, Germany and near Baden, Canton Aargau, Switzerland.

Ochetoceras vicente, new species

Specific Characters.[1]—Conch moderately flat; height of whorls about twice the width and one-half the diameter. Lateral zones flat, converging rapidly ventrad. Cross-section of whorls sagittate. Involution three-fourths; umbilicus broad. Venter

[1]Dimensions and conch ratios given in Table 3.

tricarinate; median keel high, faintly denticulate, bounded by two gently concave channels and ventro-lateral carinations. Lateral groove definite in early stages, obsolescent in gerontic stage. Costæ ventrad of groove simple, curved, crowded in young; in the half-grown conch short, fine, oblique costæ appear along the ventro-lateral angulation between the long costæ; in gerontic stage some of the long costæ become faint near lateral groove, others split ventrally into several branches, all becoming less distinct and prominent. Dorsad of groove are a few irregularly spaced folds with pronounced growth lines between them; folds increase in number on last whorl but decrease in distinctness. Sutures complex, crowded, modified by numerous small inflections throughout; six lateral lobes and saddles; lobes terminate in single point with many small accessories and are broader than saddles.

Geographical Distribution.—San Vicente, Province of Pinar del Rio, Cuba.

Ochetoceras vicente dentatum, new variety

Varietal Characters.[1]—Proportions and surface features practically the same as in *O. vicente* except that the fine intercalated costæ are not so numerous. Sutures simpler and less crowded. Distinguishing feature is the strongly noded keel.

Geographical Distribution.—Constancia, Province of Pinar del Rio, Cuba.

The Relations of *Ochetoceras vicente*

This species is the analogue in the Cuban fauna of *O. canaliferum* in the European fauna. In its early stages *O. vicente* recapitulates all of the conch proportions of *O. marantianum* and its more remote ancestor, *O. canaliculatum burckhardti*. Thus at a diameter of about 43 mm. it has nearly the same proportions as the latter has at a diameter of 55.5 mm. (see Table 3). Since the adult stage of *O. marantianum* is unknown in the Cuban fauna, comparisons must be made with the European representative of that species. *O. vicente* retains until the early gerontic stage the same ratio of width to height and this is primitively high, being over 0.50, and such as characterizes the species in older geological horizons as well as the earlier onto-stages of species in younger horizons. The involution increases with age, as in all species in this group. On the whole, the adult proportions indicate retardation. Specialization, therefore, has taken place not in trends in proportions but in the type of costal development, just as in the contemporaneous and analogous European species.

The costæ show a similar recapitulation of the successive phylo-stages: in the young of *O. vicente* they pass through *canaliculatum* and *marantianum* stages. At a diameter of 40 mm. the *canaliferum* stage begins with the appearance near the ventro-lateral angulation of fine, short, oblique costæ of the same type as those occurring in the ephebic and gerontic stages of *O. canaliferum*.

[1]Dimensions and conch ratios given in Table 3.

The sutures are crowded and complexly incised but their fundamental plan is of the *canaliculatum* type.

O. vicente dentatum retains the more primitive, finely-noded condition of keel which is characteristic of *O. marantianum*.

Ochetoceras neohispanicum Burckhardt

Specific Characters.[1]—Conch strongly compressed; whorls high and narrow with sagittate cross-section. Lateral groove faint and narrow. Dorsad of groove are faint striations and folds directed obliquely orad; ventrad of groove are falciform costæ of unequal strength, some amounting to coarse folds, the remainder being fine. Between the long costæ are striations of various lengths. Ventrad the costæ branch. Keel low, sharp, not triple. (Burckhardt, 1912, p. 46, Pl. x, figs. 1–3, 7.)

Geographical Distribution.—Cerro del Volcán, San Pedro del Gallo, Durango, Mexico.

This is the American analogue of *O. palissyanum*. The chief line of specialization in both forms is in the arrangement and number of costæ, the trend in both being toward finer and more numerous costæ with intercalated striations and ventral branching. The proportions in both species are similar but *O. neohispanicum* is not so strongly compressed as *O. palissyanum*.

Upper Kimmeridgian, Zone of *Aulacostephanus pseudomutabilis*

Ochetoceras zio (Oppel)

Specific Characters.[1]—Conch greatly compressed; whorls thin and high, cuneate in cross-section. Venter thin, unicarinate. Narrow lateral groove. Dorsad of groove, coarse radial plications; ventrad of groove, thick, falciform, simple costæ numbering 16 on last half whorl, and between every two of these, three or four finer costæ not extending to the groove but reaching the venter where they bifurcate. (Oppel, 1863, p. 196, Pl. lii, figs. 7*a–c*.)

Geographical Distribution.—Württemberg, Germany.

This species is a direct descendant of *O. palissyanum*, with which it agrees in proportions and from which it differs by the bifurcation of the small costæ; it represents the final stage of specialization in the multiplication of the costæ ventrad of the lateral groove. *Ochetoceras zio* was founded upon a single specimen, which is the only known representative of this phyletic series in the upper Kimmeridgian rocks.

GENERAL SUMMARY

The genus *Ochetoceras* is confined to the Lusitanian, Kimmeridgian, and lower Tithonian (Portlandian) divisions of the Upper Jurassic and was derived from the Middle Jurassic *Oppelia*. The numerous species

[1]Dimensions and conch ratios given in Table 3.

are found to fall into three phyletic series: (1) the series of *Ochetoceras arolicum;* (2) the series of *O. hispidum;* (3) the series of *O. canaliculatum*. In addition, there are a few forms of doubtful affinities. It is impossible to trace all of the species of *Ochetoceras* back to a single ancestral species of *Oppelia;* rather does it seem that the various phyletic series arose independently from distinct species of *Oppelia*. Douvillé pointed out that there were certain orthogenetic trends visible in the Oppelias and that *Ochetoceras* was derived from the branch in which there was a trend toward a narrow venter. Thus in the late Middle Jurassic (Oxfordian) several Oppelias developed narrow, tricarinate venters and lateral canals; from these forms the three or more branches of *Ochetoceras* developed. The *arolicum* branch is distinguished from the other two branches by its retention of the primitively smooth, *Oppelia*-like lateral zones in most onto-stages. The *hispidum* and *canaliculatum* branches are distinguished one from the other by the fundamentally divergent conch proportions and the character of the costæ of the species in each, the *hispidum* branch containing broad-whorled, coarsely costate species, the *canaliculatum* branch including compressed, high-whorled, finely costate species. The two groups cannot, therefore, be united under *O. canaliculatum* as Wepfer and others have tried to do.

The same trends in development are visible in all three series as the phylogeny is traced from the lowest Lusitanian to the Portlandian. These trends are: (1) a progressive diminution in the ratio of width to height of whorl and width of whorl to diameter; (2) a progressive diminution in the coarseness of the costæ; (3) the branching of the primary costæ at their ventral ends and finally the branching of the intercalated costæ or striæ. These trends have been observed in the onto-stages of all species in which it has been possible to study the ontogeny, so that they are onto- as well as phylo-trends; they are observable especially in the Kimmeridgian species, for in them the onto-stages of the more primitive Lusitanian forms are recapitulated. In terms of growth, these definite directions of development indicate that the adult primitive species were relatively thick-whorled forms, while the descendants in later faunas became progressively thinner and more compressed, although they still retained in their earliest onto-stages the proportions of their ancestors. (These facts are more apparent in the *hispidum* and *canaliculatum* series. Little is known about the ontogeny of any of the species in the *arolicum* series except that all of them show evidences of gerontism and therefore do not strictly adhere to the trends observable in normal, robust species.) In all of the primitive species the mantle of the animal

was nearly smooth or else thrown into coarse folds during a part of the life-time of the individual, the early stages of all primitive forms being smooth as in the ancestral *Oppelia* stock. In the descendants, the mantle folds became a more enduring feature; they were stronger, lasted longer, and were crowded back in the ontogeny. It may be suggested that the introduction of many costæ, of multiple branching, and of numerous intercalations, was in direct reponse to the crowding of the mantle into the smaller body cavity which was produced by the lateral compression of the whorls.

All of the trends which have been observed appear to be orthogenetic, for they are followed by all except decadent species in all of the phyletic series and in all of the phylo-stages. They must have been independent of environment, since they obtained in the species of the Asiatic, European, and American faunas, which by no means enjoyed uniform living conditions. The Cuban fauna, for instance, is a dwarf fauna as compared to that of the Swiss and German Jura—the dwarfing having been due to unfavorable bionomic influences—yet the species of *Ochetoceras* show exactly the same onto- and phylo-trends as do those of central Europe. The end members of all of the phyletic series arrived at nearly the same stage of development at the end of two geological epochs. Thus in the *arolicum* series *O. steraspis* from the upper Kimmeridgian and Portlandian is the analogue of *O. zio* in the *canaliculatum* series from the same horizon. In the lower Kimmeridigan we find that, in the *canaliculatum* series, *O. vicente* of Cuba is the analogue of *O. canaliferum* of Germany, Switzerland, and France, while *O. neohispanicum* of Mexico is the analogue of *O. palissyanum* of France. In the *O. hispidum* series *O. hispidiforme* of France is the lower Kimmeridgian analogue of *O. mexicanum* of Cuba and Mexico and all of these are related to the ancestral *O. hispidum* as *O. marantianum* of France and Cuba is related to the ancestral *O. canaliculatum* of Europe and America. The species of the *O. hispidum* series never passed beyond the stage of simple branched costæ to the stage of multiple branching and intercalation, which illustrates the fact that the inherent force which controls orthogenetic trends is more powerful or works more rapidly in some phyletic series than in others.

The phylogeny of the European groups of *O. hispidum* and *O. canaliculatum* was worked out in part by Oppel, Haug and Douvillé but has been modified in the present paper, as shown in Table 5. The relations of the European species in the *O. arolicum* group and of the Mexican and Cuban representatives of the *O. hispidum* and *O. canaliculatum* groups are here set forth for the first time.

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Article VIII.—THE LYCIDÆ, LAMPYRIDÆ AND CANTHARIDÆ (TELEPHORIDÆ) OF THE WEST INDIES

By Charles W. Leng and Andrew J. Mutchler

INTRODUCTION

In the following pages we aim to give a list of the species of Lycidæ, Lampyridæ, and Cantharidæ found in the West Indies, with brief description and detailed distribution of each. The number of new species that it has been necessary to describe makes it probable that the list is still incomplete, although we have had the advantage of being able to study an aggregate of specimens (more than 2000) that is probably larger than has been previously assembled. These include the collections made by the expeditions conducted by this Museum to the Bahamas, Cuba, Jamaica, Dominica, and several of the smaller islands; those made by the New York Academy of Sciences in conjunction with this Museum to Porto Rico, Mona, etc.; and those made by the expeditions, due to the generosity of Mr. B. Preston Clark, to Hispaniola, Jamaica, and the Bahamas, carried through either by Mr. W. M. Mann, or by Mr. Frank E. Watson. The collections by H. G. Barber, H. E. Crampton, F. E. Lutz, A. J. Mutchler, and F. E. Watson in Porto Rico and by F. E. Lutz in Desecheo and Mona were made on expeditions to those islands, in conjunction with the Scientific Survey of Porto Rico and the Virgin Islands by the New York Academy of Sciences. The collections of several museums and private individuals have also been studied, including that of the U. S. National Museum, loaned by the permission of Dr. L. O. Howard, Honorary Curator of Insects, and containing the specimens collected by the late H. G. Hubbard in Montserrat and those collected by Mr. E. A. Schwarz at Cayamas, Cuba. This collection embodies not only the studies of Mr. Schwarz, but also those of the late Ernest Olivier, who made exhaustive studies of certain genera. A valuable series collected in Grenada and St. Vincent was loaned by the British Museum through the kindness of Dr. Charles J. Gahan; the collection of the Academy of Natural Sciences of Philadelphia, containing the Poey Collection from Cuba, was loaned through the kindness of Dr. Henry Skinner; a collection made in the Isle of Pines was studied at the request of Dr. W. J. Holland of the Carnegie Museum. Prof. H. F. Wickham, of the University of Iowa, and Dr. Charles T. Ramsden, of Guantanamo, Cuba, furnished valuable additions to the material examined. To all these

friends and to Mr. Herbert S. Barber, of the U. S. National Museum, we extend our grateful thanks for their hearty coöperation in our work.

The collection of M. Ed. Fleutiaux from Guadeloupe and Martinique could not be studied until 1920, and then only in part, and that of Dr. Juan Gundlach, in Havana, though seen by the senior author through the kindness of Dr. Carlos de la Torre, could not be removed for study. Less than a dozen of the described species are, however, included in such unstudied material known to us.

We owe those whose material was thus borrowed an apology for the long delay in publication. This was due to several causes, among which were the puzzling questions that arose as the extensive material was studied, not alone in the surprising number of new species and new characters such as were found in the *Thonalmus* from Montserrat and the *Leptolycus* from Porto Rico, but also in the sexual characters, the number of abdominal segments, the structure of the head, etc. The greatest pains have been taken to consult the work of previous authors (though we have not attempted to enumerate all the citations) and this has disclosed some errors we have had to correct, for example, *Pygolampis* being a preoccupied name, *P. blandus* a name cited in error, etc.

We have, when known, given the collector's name (in parentheses) after the locality records. We have also indicated the collections in which the various species are located.

The figures illustrating this paper have been drawn by Mrs. E. M. Fulda for whose patient care and artistic skill we feel greatly indebted.

Definition and Preliminary Divisions

The above families include the beetles commonly known as fireflies and some allied beetles which do not emit light. They constitute the family Lampyridæ of LeConte (1881, Trans. Amer. Ent. Soc., IX, pp. 15–72) and the Malacodermidæ of Sharp (1899,'Camb. Nat. Hist.,' VI, 'Insects,' II, p. 248) except that the latter author included the Drilidæ, not represented as far as we know in America. In Dr. Sharp's opinion they are probably the most primitive of beetles, and Kolbe (1908, Zeitschr. für wiss. Inseckten Biologie, IV, p. 247), in studying the phylogeny of Coleoptera, reaches a similar conclusion.

Dr. Gahan (1911, The Entomologist, XLIX, p. 121 *et seq.*) considers the Malacodermata, one of the natural series of beetles, especially in a restricted sense, nearly equivalent to the term Lampyridæ of LeConte, comprising the Lycidæ, Lampyridæ, and Cantharidæ. Sharp and Muir (1912, Trans. Ent. Soc. London, pp. 477–642, Plates XLII–LXXVIII),

have found that they possess also a distinctive and comparatively primitive type of genitalia.

The families Melyridæ, Cleridæ, and Othniidæ, which appear to be also related, constitute the Trichodermata of Kolbe and are not included in the present study.

The Lycidæ, Lampyridæ and Cantharidæ are technically characterized by the following structures.

Seven or eight visible ventral segments. Integument softer than usual in Coleoptera, with many of the parts of the body not accurately co-adapted. The front coxæ are conical, prominent, usually large. The tarsi are five-jointed. The elytra usually cover the abdomen. The head is usually not prolonged into a beak. The antennæ are usually serrate, never lamellate. The hind trochanters sometimes intervene directly between the coxæ and the femora.

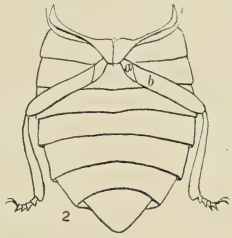


Fig. 1. Underside of a Lycid, showing attachment of femur and trochanter. *a*, trochanter; *b*, femur.

Fig. 2. Underside of a Lampyrid, showing attachment of femur and trochanter. *a*, trochanter; *b*, femur.

The definition given by Brues and Melander (1915, 'Key to the Families of North American Insects'), upon which ours is based, requires modification, for it is too precise in some respects and would exclude the larviform females of *Phengodes* and the brachypterous females of *Photinus*, as well as all the lycids with prolonged heads.

As defined above, the West Indian representatives of these families (called subfamilies by LeConte and families by Brues and Melander, Ernest Olivier, and other recent authors) may be distinguished as follows.

1. Middle coxæ distant; femora joined to the trochanters at the end of the latter (Fig. 1); elytral epipleuræ wanting, elytra usually with reticulate sculpture; thorax narrow, elongate, triangular, narrowed in front; adults not luminous. LYCIDÆ.

   Middle coxæ in contact; femora joined to the trochanters at the side of the latter (Fig. 2); elytral epipleuræ distinct . . . . . 2.

2. Episterna of metathorax sinuate on the inner side; head nearly or quite covered by the thorax; epipleuræ usually wide at the base of the elytra; abdomen of adults more or less luminous . . . . . LAMPYRIDÆ.

Episterna of metathorax not sinuate; head not at all covered by the thorax which is short, rounded at sides and front angles, squarely truncate at base; epipleuræ narrowed at base of elytra; adults not luminous.

CANTHARIDÆ (Telephoridæ *auct.*).

The figures given by Olivier (1911, Rev. Sci. du Bourbonnais, XXIV, p. 108) will assist in the technical separation of the families, but the general resemblance of most of the species to a few well-defined types renders this easy in practice. There are a few extremely specialized forms to which attention should be drawn, such as *Leptolycus* (p. 430), *Thonalmus hubbardi* (p. 426), and some species of *Belotus* and *Silis* (pp. 486–489 and 490–492), in which extraordinary structures, not mentioned in the key to the families, are found.

Geographical Distribution

Each of the three families treated in this paper has representatives in all the zoölogical regions. There is, however, a fourth family, Drilidæ, which is confined, as far as we know now, to the Old World; and recent authors recognize also, in *Phengodes* and allied genera, a fifth family, Phengodidæ, which is confined to continental America. The families are divisible into tribes which have a narrower distribution, some of these tribes, as we show later, being confined to the American continent.

LYCIDÆ

Division and Distribution of Lycidæ

Following LeConte (*loc. cit.*, 1881) the species of Lycidæ fall into tribes which may be distinguished as follows.

1. Prothoracic spiracle with elevated chitinous peritreme (Fig. 3), more or less prominent in the usual position of the epimeron, behind and at the outer extremity of the front coxæ (*Calopteron*), or, if the spiracle is not distinctly prominent, pronotum with a median carina in front, continued posteriorly by a median channel[1] (*Thonalmus*) ..... LYCINI.
   Prothoracic spiracle not prominent; pronotum never channeled ..... 2.
2. Elytra costate, cancellate or reticulate ..... EROTINI.
   Elytra dehiscent, pubescent; antennæ with long hairs ..... LEPTOLYCINI.

Fig. 3. Head of *Calopteron*, side view. *a*, peritreme.

We are obliged to add the last tribe for the remarkable genus described below (p. 430). Of these tribes, the Lycini are represented by two closely related genera, *Calopteron* and *Thonalmus*, readily separated by the coloration; the Erotini by one genus,

[1]There are some *Calopteron*, found in localities outside of the West Indies, in which the median carina is continued posteriorly by a median channel, but we believe this character, combined with the color pattern, will hold good for all of the species of *Thonalmus*.

Plateros; and the Leptolycini by one genus, *Leptolycus.* The last is peculiar to the West Indies. The Lycidæ as a whole are numerous throughout tropical Africa and South America, extending to Madagascar and Australasia; in the Palæarctic and Nearctic regions a few species extend their range to the most northern parts thereof, and still fewer occur in eastern Asia. The West Indian species exhibit a strong individuality but also in many cases a relation with those inhabiting the American continent.

Lycini

This tribe is represented by two genera, separable as follows.

Elytra orange or bright red, with the posterior part only bluish green or metallic violet ..... *Thonalmus.*

Elytra yellow with black markings, sometimes faintly metallic ..... *Calopteron.*

Calopteron is widely distributed in North and South America, and allied genera occur in Africa and Australasia. The separation of *Thonalmus* is based upon feeble characters; in addition to those given above, the prothoracic spiracle is less prominent and the pronotal carina is channeled posteriorly; there are usually fewer elevated costæ on the elytra; and the abdominal characters discovered by the junior author in the Montserrat species (see pp. 421 and 426) are, as far as known, unparalleled elsewhere.

Thonalmus Bourgeois

1883, Ann. Soc. Ent. France, (6) III, p. 376

The West Indian species were first detached from *Calopteron* by Waterhouse, 1878, Trans. Ent. Soc. London, p. 98, but the description of the genus appears to be due to Bourgeois. They are all elongate, glabrous insects, with long, feebly serrate antennæ (or slightly branched in the male of one species), and subparallel elytra, usually bearing three more or less elevated ridges or costæ. The elytra are of a brilliant orange or red color, with the posterior portion metallic green or violet.

The species are numerous, quite closely related, and therefore difficult to separate; all are confined to the West Indies, most of them to a single island. Although in the original description of *bicolor* Linnæus gave the type locality as Africa, which locality was also cited by the earlier authors, we believe he did so in error and the statement that *Thonalmus* is exclusively West Indian to be correct. The first citation of a West Indian locality we have been able to find is that by Gosse, 1848, Ann. and Mag. Nat. Hist., (3) I, p. 268. The work of Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 73, also serves to fix the true locality of this

species as the West Indies. A translation of one paragraph in Chevrolat's article reads "The study which I have made of the authors has convinced me that four different species have been described under this name and that the old writers (*les anciens*) have wrongly designated Africa as the habitat of these species, the group in reality belonging to the Antilles."

Including the species described below, we now have records of two from Guadeloupe, two from Montserrat, one from Jamaica, none from Porto Rico (except by recent commercial importation), two from Hispaniola, three from Cuba (three more have been described but we believe one of them to be a synonym and the others color variations), and one from the Bahamas. We know of none from Florida, none from the islands south of Guadeloupe, nor from the islands between Porto Rico and Montserrat, in which, however, (judging from the discovery by the late Mr. Hubbard of peculiar species in the latter island) there may be still undescribed species. The apparent failure of the genus to have become established in Porto Rico is singular.

The preponderance of females in the large series we have examined is also remarkable. The males are easily distinguished by examining the penultimate ventral segment, which in that sex is so deeply incised at the middle as to consist of two side lobes embracing the last segment. In one species our collections show a preponderance of males, but in all other cases the females are greatly in excess of males.

Two sections of the genus can be recognized, the one containing species with strongly costate elytra, the other species with merely a trace of costæ; and it is interesting to note that the species of the second section are confined to Cuba and the Bahamas. The following key, based in part upon this character, is as complete as we have been able to devise; the separation of most of the described species is comparatively easy, but *aulicus*, *elegantulus*, *distinguendus*, and *nigritarsis* show no differences except in size and color pattern of the legs. As these differences are bridged in the large series before us, we are compelled to regard them as one species but for convenience have included the last two names as color varieties.

KEY TO THE SPECIES OF *Thonalmus*

1. Apical third of elytra bluish green or metallic violet ..... 2.
   Apical half of elytra bluish green or metallic violet ..... 7.
2. Scutellum subquadrate ..... 3.
   Scutellum triangular; hind margin of pronotum elevated at middle; head black; basal part of elytra orange in color, not vermilion ..... *bicolor.*
3. Basal part of the elytra red; head concolorous with pronotum ..... 4.
   Basal part of elytra orange; head black ..... *subquadratus.*

4. Elytra subparallel; costæ not or at most feebly elevated on apical part of elytra . 5.
   Elytra expanded apically; outer and middle costæ abruptly elevated, forming two crests on the apical part of each elytron . . . . . *dominicensis.*
   Elytra expanded apically; outer and middle costæ somewhat strongly elevated, but not forming crests on any portion of the elytra . . . . . *chevrolati.*
5. Outer and middle costæ not united into a curve on the apical portion of the elytra . . . . . 6.
   Outer and middle costæ united into a rounded curve on the apical portion of the elytra . . . . . *suavis.*
6. Antennæ of male slightly branched from joint 4 to joint 10; antennæ of female serrate . . . . . *amabilis.*
   Antennæ of both sexes serrate; femur red nearly to the apex, tibiæ and tarsi black; length 8.5 to 12.5 mm . . . . . *aulicus.*
   [Base of femur red, legs otherwise black, length 6 to 10 mm . . . var. *distinguendus.*
   Femur and tibia in great part red, length 6 to 10 mm . . . . . var. *nigritarsis.*]
7. One or more elytral costæ prominent throughout their entire length; female with abdominal processes . . . . . 8.
   Costæ of the elytra barely traceable on the apical portion; humeral angles not sharply defined; female without abdominal processes . . . . . *bahamæ.*
8. Third abdominal segment of female with a chitinous lobe or process, extending from the middle of the segment to near its lateral margin; elytral costæ somewhat prominent, the middle one less so basally . . . . . *hubbardi.*
   Third abdominal segment of female with a chitinous lobe or process extending from the middle of the base to near the side; elytra each with a sinuate costa starting at the humerus and gradually diverging from the margin until it reaches the middle of the violet apical area, where it curves outward, reaching the apex some distance from the suture. There is also a short costa parallel to the apical portion of the main costa and sometimes joined to it . . . . . *sinuaticostis.*

Thonalmus bicolor (Linnæus)

Cantharis bicolor Linnæus, 1763, Amœn. Acad., VI, p. 395.
Lampyris bicolor Linnæus, 1767, 'Syst. Natura,' 12th Ed., I, part 2, p. 646.
Pyrochroa bicolor Fabricius, 1775, 'Syst. Entom.,' p. 203; 1781, 'Spec. Insect.,' I, p. 255; 'Mant. Insect.,' I, p. 163.
Lycus bicolor G. A. Olivier, 1789, 'Entomologie,' II, No. 29, p. 9, Pl. I, figs. 9*a–b*. Fabricius, 1792, 'Entom. Syst.,' I, part 2, p. 108; 1801, 'Syst. Eleuth.,' II, p. 113. Coquebert, 1804, 'Illustr. Iconog. Insect.,' III, p. 128, Pl. xxix, fig. 4. Schönherr, 1817, 'Syn. Insect.,' I, part 3, p. 77.
Lycus militaris Dalman, 1817, in Schönherr's 'Syn. Insect.,' I, part 3, appendix, p. 30.
Calopteron bicolor Gosse, 1848, Ann. Mag. Nat. Hist., (2) I, p. 268.
Calopteron denominatum Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 74.
Thonalmus militaris Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 378.
Thonalmus bicolor Fleutiaux and Sallé, 1889, Ann. Soc. Ent. France, (6) IX, p. 415. Gorham, 1898, Proc. Zoöl. Soc. London, p. 317. Bourgeois, 1901, Ann. Soc. Ent. France, LXX, p. 50.

Orange, with the head (excepting a small spot between the antennæ), antennæ and legs (excepting basal half of femora) black. Scutellum triangular. Elytra black-

ish blue in apical third; tricostate. Length, 6–10 mm., the smaller size being exceptional.

This is the only species of the genus with triangular scutellum; it has the base of the pronotum more elevated and the head more prolonged than any of the other species.

Recorded from Jamaica by Dalman, Bourgeois, Chevrolat, and Becker; from Guadeloupe by Fleutiaux; and, in error, from Africa by Linnæus. We have seen specimens from the following localities in Jamaica. Coll. U. S. Nat. Mus.: no definite locality, (Hubbard). Coll. Acad. Nat. Sci. Philadelphia: Bath. Coll. H. F. Wickham: Mandeville, April. Coll. Amer. Mus. Nat. Hist.: Kingston, July, (Wirt Robinson); Hope Gardens, February, and Montego Bay, March, (J. A. Grossbeck); Montego Bay, December, Dunrobin District, Clarendon, December, and Constant Spring, January, (F. E. Watson); Constant Spring, May or June, (H. E. Machado). Gosse recorded it as excessively abundant in June, 1845 and 1846, sometimes hundreds on a single tree, resting principally on horizontal branches at the forest edge each side of Hampstead Road, Jamaica.

There has been some confusion respecting the description by Linnæus of this species, which may account for the erroneous (?) records from Haiti by Chevrolat in 1870. We have followed the opinion of Bourgeois, based on information received from M. René Oberthur, that the true *bicolor* of Linnæus is the Jamaican insect.

Thonalmus subquadratus, new species

Figure 4

Head and antennæ black, the later with a moderate covering of erect yellowish hairs. Thorax, scutellum, and basal two-thirds of elytra orange-yellow; apical third of elytra violet or bluish green with a metallic lustre. Thorax wider at base than long with an impression at each side reaching from base to front angles; lateral and basal margins elevated; apex with a carina divided at basal third. Scutellum subquadrate; deeply notched at apex in the male, broadly emarginate in the female. Elytra with the outer costæ well defined at the humeri and remaining somewhat prominent throughout their length; middle costæ not so well defined at the base but becoming more so after reaching the apical third; inner costæ evident at the base, entirely obliterated in apical third. Body beneath yellow; male with last ventral segment black. Legs black, excepting basal part of femora, which is orange-yellow; the yellow color on the first pair being confined to a comparatively small part, that on the middle pair to about one-third, and that on the hind pair covers one-half to two-thirds of each. Length, 6–8 mm.

Occurs in Jamaica. None of our specimens has more definite locality data.

Holotype male and one female paratype in the collection of U. S. National Museum, both collected by the late H. G. Hubbard. Allotype female, No. 24517, in

collection of The American Museum of Natural History, collected by Col. Wirt Robinson.

This species is quite similar to *T. bicolor* in appearance, but differs in having the scutellum subquadrate and in the basal margin of the pronotum being less elevated and broadly rounded at the middle.

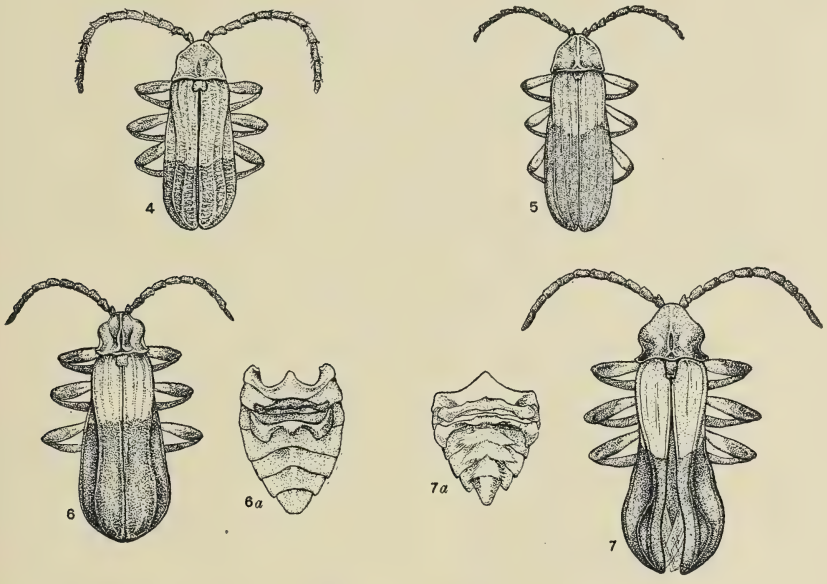


Fig. 4. *Thonalmus subquadratus*, new species.
Fig. 5. *Thonalmus bahamæ*, new species.
Fig. 6. *Thonalmus hubbardi*, new species.
Fig. 6*a*. *Thonalmus hubbardi*, underside of female, showing ventral processes.
Fig. 7. *Thonalmus sinuaticostis*, new species.
Fig. 7*a*. *Thonalmus sinuaticostis*, underside of female, showing ventral processes.

Thonalmus dominicensis (Chevrolat)

Charactus blandus Dejean, 1873, 'Catalogue des Coléoptères,' III, p. 112 (no description).

Calopteron bicolor Castelnau, 1840, 'Hist. Nat. et icon. Coléop.,' I, p. 282.

Calopteron dominicense Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 73.

Thonalmus dominicensis Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 377. Gorham, 1889, Proc. Zoöl. Soc. London, p. 317. Fleutiaux and Sallé, 1889, Ann. Soc. Ent. France, (6) IX, p. 415. Bourgeois, 1901, Ann. Soc. Ent. France, LXX, p. 50.

Luteous red; palpi, antennæ, and tarsi black; posterior third of elytra blackish blue or greenish blue. Each elytron with three elevated lines, of which the outer two are cristate before the apex; the intervals between the elevated lines reticulate. Length, 8–12 mm., few specimens being less than 10 mm. in length.

In the majority of the specimens of this species the anterior margin of the blue portion of the elytra is less regular than in the species that follow; but the best character for separating it from allied species is the strongly elevated crests near apex of elytra.

Chevrolat records the species from Santo Domingo and says that, according to Sallé, it is common near the city of Santo Domingo, but is found over the whole island. We have seen specimens from the following localities in Hispaniola. Coll. U. S. Nat. Mus.: Romano, April, (W. V. Tower); Higueral, April, (J. R. Johnston); Sanchez, April and November, (P. G. Russell); San Francisco Mts., September, (Aug. Busck). Coll. H. F. Wickham: Port au Prince, (R. J. Crew). Coll. Amer. Mus. Nat. Hist.: San Lorenzo, June, and Sanchez, March and April, (F. E. Watson); Higueral, February, (E. G. Smyth);[1] and specimens merely labeled "Haiti."

Thonalmus chevrolati Bourgeois

Calopteron bicolor Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 73.
Thonalmus bicolor Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 378.
Thonalmus chevrolati Bourgeois, 1901, Ann. Soc. Ent. France, LXX, p. 50.

Red with apex of elytra violaceous. Antennæ compressed; black, first joint partly red. Elytra expanded and with costæ somewhat strongly elevated, but not forming crests on apex of elytra. Length, 8–12 mm.

This species resembles the preceding ones in size and coloration, but lacks the elevated elytral crests of *dominicensis* and the elevated prothoracic hind margin of *bicolor*. In the majority of the specimens examined, the blue portion of the elytra is transversely limited in front with but little irregularity in its outline.

Occurs in Hispaniola and, by commercial introduction only, in Porto Rico.

Chevrolat (1870) gives "Saint-Domingue, San-Yago, Collection de l'auteur. Exemplaire de la collection d'Olivier." Bourgeois (1883) says "Saint-Domingue (Hogard Mission du Saint-Esprit: Coll. Bosc. 1828; Sallé, 1851. ♂ ♀." We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: Romano, Dominican Republic, April, (W. V. Tower). Coll. H. F. Wickham: Port au Prince, Haiti, (R. J. Crew). Coll. Amer. Mus. Nat. Hist.: San Lorenzo, Dominican Republic, June, (F. E. Watson); Higueral, Dominican Republic, February, (E. G. Smyth); Guanica, Porto Rico, April, in a boat-load of cane from Higueral, (R. H. Van Zwaluwenburg).

[1]All of the above localities, excepting Port au Prince, are in the Dominican Republic part of the island of Hispaniola, but in the published records of some species we are unable to say to which part of the island they refer.

Thonalmus suavis (Jacquelin Duval)

Charactus elegans Dejean, 1837, 'Catalog. Coléop.,' 3 Ed., p. 112 (no description).

Calopteron suave Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 80. Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 75. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 254.

Thonalmus suavis Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 378. Gorham, 1898, Proc. Zoöl. Soc. London, p. 317. Bourgeois, 1901, Ann. Soc. Ent. France, LXX, p. 51.

Red; hind part of elytra blue; antennæ and legs, except base of femora, black. Costæ of elytra not strongly elevated; the submarginal one is curved in its posterior third; the second one is almost straight. Length, 7.6–11 mm.

Distinguished from closely related species by the form of the elytral costæ, which are not strongly elevated and coalesce at the apex of the elytra. The anterior margin of the blue color of the elytra forms a nearly regular curve. The blue color is also slightly more advanced on each elytron than in the preceding species.

Confined to Cuba. Chevrolat (1870) says "Cuba, Collections de M. M. Guérin-Méneville (types ♂), Gundlach et Poey." Gundlach (1894) records it as found throughout the island. We have seen specimens from the following Cuban localities. Coll. U. S. Nat. Mus.: Cayamas, February, March, April, May and December, (E. A. Schwarz); Baracoa, August and September, (Aug. Busck); near Guantanamo, (C. F. Baker). Coll. Acad. Nat. Sci. Philadelphia: Guantanamo, February, (Henry Skinner); Santa Ana, March. Coll. H. F. Wickham: Isle of Pines, December, (Oertel); Bahia Honda, June. Coll. Amer. Mus. Nat. Hist.: Guantanamo, April, at light, (Chas. T. Ramsden); Cabañas and Zaza del Medio, September, (Lutz and Leng); Guantanamo, October, (F. E. Lutz); Delcias, March, (S. Bevin); Santiago.

According to Mr. E. A. Schwarz, this species is more abundant in the spring of the year.

Thonalmus amabilis (Jacquelin Duval)

Calopteron amabile Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 80. Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 75. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 254.

Thonalmus amabilis Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 379. Gorham, 1898, Proc. Zoöl. Soc. London, p. 317. Bourgeois, 1901, Ann. Soc. Ent. France, LXX, p. 51.

Red. Antennæ of male with joints four to ten inclusive, slightly branched. Elytra subparallel; apex blue; costæ not united at apical portion of the elytra. Length, 6–9 mm.

Coloration as in preceding species. Differs by the male antennæ having each joint from the fourth to the tenth inclusive provided with a small branch from its apical angle; and by the elytral ridges failing to unite at apex, though they are as strongly elevated nearly to their extremity. The female is not easily separated from the same sex of *T. aulicus.*

Confined to Cuba. Chevrolat (1870) says "Cuba. Collections de M. M. Guérin-Méneville (types), Gundlach, Poey." Bourgeois gives "Cuba; Mayari (baie de Nipe) [Chapter, 1883]. ♂, ♀." Gundlach (1894) records it as living in both halves of the island. We have seen specimens from the following Cuban localities. Coll. U. S. Nat. Mus.: Cayamas, May and December, (E. A. Schwarz); Guantanamo (C. F. Baker). Coll. Carnegie Mus.: Nueva Gerona, Isle of Pines, May, (G. Link). Coll. Amer. Mus. Nat. Hist.: Guantanamo, April, (Chas. T. Ramsden and F. E. Lutz).

Thonalmus aulicus (Jacquelin Duval)

Calopteron aulicum Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 80. Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 76. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 255.

Calopteron elegantulum Jacquelin Duval, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 80. Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 76. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 255.

Thonalmus aulicus Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 379. Gorham, 1898, Proc. Zoöl. Soc. London, p. 317. Bourgeois, 1901, Ann. Soc. Ent. France, LXX, p. 51.

Thonalmus elegantulus Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 380.

Red. Antennæ black, basal joint sometimes wholly red, or with two or three of the basal joints more or less marked with red. Elytra at posterior part either metallic blue or coppery green. Legs black, excepting base of femora which are red nearly to the apex. Length, 8.5–12.5 mm.

This species and the following two color varieties are generally of a bright red color, but they sometimes become dull red in dried specimens.

Confined to Cuba. Gundlach (1894) gives Cardenas for the locality of *aulicus* but says *elegantulum* is found throughout the island. Bourgeois (1901) says "Cuba (de Brémond, 1839); idem: Mayari (baie de Nipe) [Chaper, 1883]." We have seen specimens from the following Cuban localities. Coll. U. S. Nat. Mus.: Cayamas, February and May, (E. A. Schwarz); Cayamas, April, (Dimmock); Jovellanos, March, (Hunter). Coll. Acad. Nat. Sci. Philadelphia: Santa Ana, March. Coll. Amer.

Mus. Nat. Hist.: Havana, May, (Cook); seven kilom. north of Viñales, (F. E. Lutz); Guantanamo, April, at light, and June, (Chas. T. Ramsden), also October, (Lutz and Ramsden).

Thonalmus aulicus var. **distinguendus** (Jacquelin Duval)

Calopteron distinguendum Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. et L'île de Cuba,' Anim. Artic., p. 80. Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 77. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 256.

Thonalmus distinguendus Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 379. Gorham, 1898, Proc. Zoöl. Soc. London, p. 317. Bourgeois, 1901, Ann. Soc. Ent. France, LXX, p. 51.

Legs black, base only of femora red. Length, 6–10 mm.

As stated in the discussion of the genus, we can not find any characters to separate this and the following form from the above species and therefore cite them merely as color varieties.

Recorded from Cardenas and Trinidad, Cuba, by Gundlach. We have seen specimens from the following Cuban localities. Coll. U. S. Nat. Mus.: Cayamas, May and June, Havana, March, (E. A. Schwarz); Baracoa, September, (Aug. Busck). Coll. Amer. Mus. Nat. Hist.: Guantanamo, October, and Cabañas, September, (F. E. Lutz); Havana, May and August, (Mel. T. Cook); Santiago de Cuba.

Thonalmus aulicus var. **nigritarsis** (Chevrolat)

Calopteron nigritarse Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 77. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 255.

Thonalmus nigritarsis Bourgeois, 1883, Ann. Soc. Ent. France, (6) III, p. 380; 1901, idem., LXX, p. 51.

Femora and tibiæ in great part red; tarsi, only black. Length, 5–10 mm.

Recorded from Cardenas, Cuba, by Gundlach and, erroneously we believe, from Haiti by Jacquelin Duval. We have seen specimens from the following Cuban localities. Coll. U. S. Nat. Mus.: Cayamas, Cuba, February, March and May, (E. A. Schwarz). Coll. Acad. Nat. Sci. Philadelphia: Cuba, (Poey Coll.).

Thonalmus bahamæ, new species

Figure 5

Elongate; subparallel. Head, thorax, body beneath, and basal half of the elytra reddish yellow. Antennæ black; basal joints tinged with reddish yellow. Palpi black. Elytra with the posterior part purplish or greenish blue; costæ very feeble, barely traceable on the posterior half of the elytra; humeri as sharply angled as usual. Legs variable in color; the femora red at base, or red for nearly the whole length; tibiæ dark, often partly red or tinged with red; tarsi always dark. Length, 5–9 mm.

Nineteen specimens from New Providence, near Blue Hills, Bahama Islands, May 31, 1904, (W. M. Wheeler), and fourteen specimens, Andros Island, Fresh Creek and Mangrove Cay, May and June, 1917, (W. M. Mann).

Holotype male, No. 24519; allotype female, No. 24520; and paratypes, Nos. 24521 to 24524 inclusive; Coll. Amer. Mus. Nat. Hist. Paratypes, a male and a female, have been deposited in the U. S. National Museum.

This species is generally smaller than any other species known to us. The blue color of the elytra extends from the apex quite to the middle of the elytra; in this respect it resembles the species of Montserrat, but in the absence of strong elytral costæ it resembles the Cuban species.

Thonalmus hubbardi, new species

Figures 6 and 6*a*

Elongate. Yellow. Antennæ, tarsi, tibiæ and apices of femora black; apical half of elytra blue. Basal margin of prothorax arcuately elevated at middle. Elytra with three strongly elevated costæ, of which the outer is entire and slightly sinuate, the middle one obsolete at base, the inner obsolete at apex; the outer margin and suture are also moderately elevated. Ventral abdominal segments of male similar to those of other species of the genus; those of female, however, very different, the first and second segments being elevated at middle forming a crest, the second segment also with a process attached to the middle of its base, which process occupies about two-thirds the width of the segment and extends nearly to the side margins. Attached to the center of the third segment is a chitinous process which extends towards each side to about three-fifths the width of the segment which, at the point of attachment, is triangular and then becomes somewhat suddenly constricted and again broadens out into a somewhat triangular shape with a broad curved base and acutely pointed apex, the points being directed toward the basal segment (Fig. 6*a*). The middle of the fourth, fifth, and sixth segments pubescent. Length, 9–12 mm.

Montserrat, March 2, 11 and 21, 1894 (H. G. Hubbard).

Holotype male, allotype female, and paratypes (four males and one female) in Coll. U. S. Nat. Mus. Three males and one female, paratypes, Nos. 25072 and 25073, in Coll. Amer. Mus. Nat. Hist.

This species resembles in some respects *T. bicolor* from Jamaica but differs in having half, instead of a third, of the elytra blue, in the absence of the sharp elevation of the hind prothoracic margin at middle, and in possessing the female ventral processes. The discovery of these processes in this, and the next species, is due to the junior author's study of the morphology of the specimens; they seem to be quite unique in Coleoptera.

Thonalmus sinuaticostis, new species

Figures 7 and 7*a*

Elongate. Yellow. Antennæ, tarsi, tibiæ and apices of femora black. Apical half of elytra blue. Basal margin of prothorax arcuately elevated at middle. Elytra with a strongly elevated costa, starting at the humerus and gradually diverging from the margin until it reaches the middle of the blue area, where it curves outward and

ends in an arc which reaches the apex at a distance from the suture; also with a shorter, arcuate costa, running parallel to the curved portion of the outer costa, and between it and the suture, ending at the sutural angle; also with the outer margin of the elytra moderately elevated. Ventral abdominal segments of the male similar to those of other species of the genus; those of female, however, very different, the first and second segments being elevated at middle forming a crest, the second segment with a process attached to the middle of its base, which occupies about two-thirds the width of the segment and extends nearly to its side margins. Attached to the center of the third segment is a chitinous process which extends towards each side to about three-fifths the width of the segment which, at the point of attachment, is triangular and then becomes somewhat suddenly constricted and again broadens out into an ovate mass, the apices of which are pointed toward the apical segments (Fig. 7*a*). The middle of the fourth, fifth and sixth segments is densely pubescent in the female. Length, 9–13 mm.

Montserrat; March 1 and 21, 1894 (H. G. Hubbard); December 17, 1906 (H. A. Ballou, No. 885).

Holotype male, allotype female, and three female paratypes in Coll. U. S. Nat. Mus. One male and two female paratypes, Nos. 25074 and 25075, in Coll. Amer. Mus. Nat. Hist.

The outer costa on each elytron is much more prominent and sinuate and the pubescence on the fourth, fifth and sixth ventral abdominal segments is much denser than in *hubbardi*. In some specimens the shorter inner costa is lacking, or more or less consolidated with the outer costa.

Calopteron Guérin

1830, 'Voyage Coquille,' p. 72

The few species of *Calopteron* described from the West Indies are black, with the upper surface and prothorax yellow, and the elytra yellow with black markings, never blue as in *Thonalmus*, and seldom with the metallic sheen characteristic of that genus. *Calopteron* is represented by numerous species on the mainland of North and South America, from whence it appears to have spread to the southern West Indian islands of Grenada, St. Vincent, and Guadaloupe. The species *semiflavum*, described from Cuba by Chevrolat, has not been seen but, from the description, seems certainly to belong to some other genus.

Calopteron oblitum Gorham

Figure 8

Calopteron oblitum Gorham, 1898, Proc. Zoöl. Soc. London, p. 316.

Black; prothorax and elytra dirty yellow. Elytra with the apical third and the suture as far as the second costa more or less black. Antennæ of female strongly serrate. Length, 8–10 mm.

Grand Etang, Grenada; Kingstown and windward side up to an elevation of 1500 feet, St. Vincent; Coll. British Mus.

Our figure is drawn from specimen kindly loaned by the British Museum.

Calopteron delicatum Kirsch

Figure 9

Calopteron delicatus Kirsch, 1865, Berliner Ent. Zeit., IX, p. 61. Bourgeois, 1879, Ann. Soc. Ent. France, (5) IX, p. 37. Gorham, 1898, Proc. Zoöl. Soc. London, p. 316.

Black. Thorax yellow, longitudinally black at middle. Elytra yellow, with the suture in front, a complete fascia before the middle, and apex, broadly, black. Length, 7–10 mm.

Balthazar, Mt. Maitland, and Chantilly Estate, Grenada; Coll. British Mus.

Our figure is drawn from specimens kindly loaned by the British Museum.

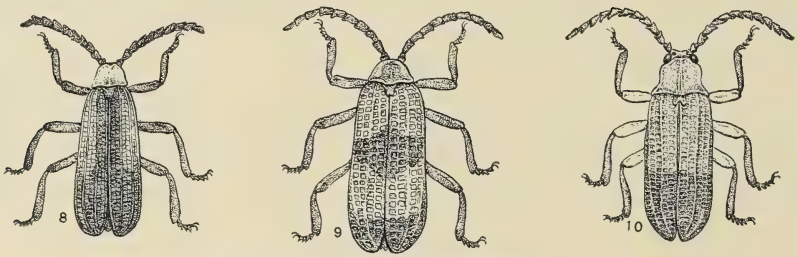


Fig. 8. *Calopteron oblitum* Gorham.
Fig. 9. *Calopteron delicatum* Kirsch.
Fig. 10. *Calopteron pectinicornis* Chevrolat.

Calopteron smithi Gorham

Calopteron smithi Gorham, 1898, Proc. Zoöl. Soc. London, p. 315, Pl. xxxvii, fig. 2.

Black. Sides of prothorax and elytra orange, the latter with a large common black dorsal spot scarcely reaching either margin; apex black. Antennæ scarcely serrate. Length, 6–10 mm.

St. Vincent, (H. H. Smith); Coll. British Mus.

Similar to *C. delicatum*. The central black spot of the elytra, however, always reaches the margin in *delicatum*, and the suture, from the central spot to the base, is sometimes black in that species; in *smithi*, the central black spot is less extended and the suture is never black.

Calopteron pectinicornis Chevrolat

Figure 10

Calopteron pectinicornis Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 74. Fleutiaux and Sallé, 1889, Ann. Soc. Ent. France, (6) IX, p. 415.

Elongate. Head, thorax, scutellum, and about the basal three-fifths of the elytra yellow. Antennæ strongly serrate, almost pectinate; compressed; black excepting

the basal joint which is flavous. Palpi yellow at base; apex black. Head impressed at the front between the base of the antennæ and labrum; antennal tubercles somewhat prominent above; vertex somewhat flattened finely punctate and pubescent. Thorax wider at base than long; apex rounded; sides arcuately emarginate, margin reflexed; disk impressed more deeply near the base, and with a raised median line; base bisinuate, angles acute. Scutellum broadly incised at the middle of the apex. Elytra with sutural and lateral margin raised, and with two well-defined and two ill-defined costæ, between which are transverse lines forming more or less quadrate cells; apical two-fifths black; apex moderately narrowly rounded. Underside of thorax yellow. Ventral segments of the abdomen, black. Femora yellow; tibiæ and tarsi, black. Length, 5.5–8 mm.

This description and the drawing were made from two specimens collected by Vitrac and Delauney from the type locality (Guadeloupe) and kindly loaned to us by M. Ed. Fleutiaux.

Calopteron (?) **semiflavum** Chevrolat

Calopteron (?) *semiflavum* Chevrolat, 1870, Ann. Soc. Ent. France, (4) X, p. 78.
Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 256.

The following is a translation of Chevrolat's description of this species.

Small, elongate, flat, black, with last joint of antennæ and anterior third of the elytra yellow. Head free, subquadrate, anterior margin crassate, reflexed, transversely sulcate. Eyes placed laterally, small and globose. Antennæ compressed broad. Prothorax subquadrate, reflexed anteriorly and posteriorly; sides oblique; with three longitudinal furrows; with posterior angles cut off straight behind; divaricate and acute. Scutellum quadrate; black. Elytra rugose; twice as wide as the prothorax; flat, obtusely rectangular at the humeri, parallel, each of them rounded, each elytra with three elevated lines; humeral line carinate; black, base yellow. Femora and tibiæ flattened; canaliculate. Length, 2.66 mm., width, .5 mm.

Cuba. Collections Gundlach and Poey.

This pretty and very small species should probably constitute a distinct genus, on account of its head not being covered and free from the prothorax and its broadened flat antennæ, which are longer than the elytra.

This species may be a female belonging to our genus *Leptolycus*, though evidently not the same as the Porto Rican species.

Not seen by us in Poey collection in Philadelphia. Gundlach (1894) records it from Rangel.

Erotini

This tribe, well developed on the mainland, is represented in the West Indies by two species of the genus *Plateros* which occur in St. Vincent.

Plateros Bourgeois

1879, Ann. Soc. Ent. Belgique, XXII, Comptes-Rendus, p XIX

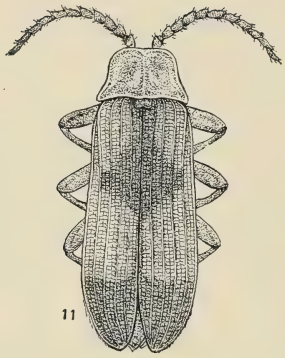


Fig. 11. *Plateros palliatus* Gorham.

Plateros palliatus Gorham

Figure 11

Plateros palliatus Gorham, 1898, Proc. Zoöl. Soc. London, p. 317.

Head, antennæ, and body black. Pronotum yellow; wider at base than long; disk with a deep central channel. Elytra yellow at the humeri and margins, black at apical fourth and with a large sub-basal black spot. Length, 9–10 mm.

St. Vincent, (H. H. Smith); Coll. British Mus.

Our figure is drawn from a specimen kindly loaned by the British Museum.

Plateros fraternus Gorham

Plateros fraternus Gorham, 1898, Proc. Zoöl. Soc. London, p. 317.

Black. Thorax and scutellum yellow, shining. Elytra yellow, with the basal third and apical fourth blackish. Length, 7.5–8 mm.

Recorded by Gorham from St. Vincent, (H. H. Smith).

This species is said to mimic the markings of *Photinus notatus*. We regret that we have not seen it.

Leptolycini

This tribe is erected to contain the new genus described below.

Leptolycus, new genus

Body small and delicate. Head large, gibbous; mouth-parts beneath; eyes globose, distant, coarsely granulated. Antennæ long; subserrate in female, slightly angulate at apex of each joint and with flying hairs in male. Thorax trapezoidal, narrowed in front, very narrow beneath in male. Elytra strongly dehiscent, entire, separately rounded at apex. Coxæ not contiguous, small, globular, borne at apex of tubular protuberances; trochanters slender, intervening between coxæ and femora and more than a fourth as long as femora.

Leptolycus heterocornis, new species

Figures 12 and 12*a*

Black. Basal fifth of elytra yellow. Last joint of antennæ entirely white in the male; white, tipped with black in the female. Head coarsely granulate; sides parallel, projecting strongly beyond the eyes and bent so that the front is oblique and the mouth-parts entirely beneath, these parts in the male with many long black hairs. Eyes prominent, globose, coarsely granulate, similar in both sexes; distant above, more approximate beneath. Antennæ with the scape short, stout and thick, and the second and third joints also very short in both sexes; joints three to eight, nearly equal in length, different in the sexes; in the male (Fig. 12), linear, with uneven sur-

face, from the elevations of which proceed long hairs; in the female (Fig. 12*a*), flattened, subserrate and pubescent; the last joint is rounded at the apex in both sexes. Thorax black, granulate, conical, truncate in front, sinuate on the sides; twice as wide behind as in front; base bisinuate; hind angles prominent, produced but not acute. Seen from the side, the surface of the pronotum is deeply concave at middle and the anterior and posterior margins are elevated, the latter standing far above the elytra. The thorax beneath differs in form in the sexes, the male being much shorter and bearing granulate and hairy, tubular extensions, which support the legs. Elytra as long as the abdomen; yellow in basal fifth, black elsewhere; silky with fine pubescence; rounded at humeral angles; separated at base by the large black scutellum and throughout their length by their extreme dehiscence; broader than thorax at base; becoming rapidly narrower and separately rounded at their apices. The wings, which are also clothed with short hairs but more sparsely, project beyond the elytra. Legs long, flattened, clothed with short hair; coxæ small, globular; trochanters about half as long as tarsi, slender, feebly arcuate, cylindrical; femora elliptical, flattened, slightly bent; tibiæ longer, slightly broader at apex; tarsi with first joint short, second about twice as long as first, joints three and four together about equal to second, fifth longer and about equal to second, all slender, cylindrical, hairy; claws simple. Abdomen black, pubescent; penultimate segment of male emarginate, as is usual in the Lycidæ. Length, 3 mm.

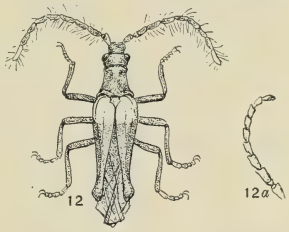


Fig. 12. *Leptolycus heterocornis*, new species, male.

Fig. 22*a*. *Leptolycus heterocornis*, antennæ of female.

Porto Rico: Aibonito, July 14–17, 1914, (H. G. Barber); Cayey, May 31, 1915, (Lutz and Mutchler). Both localities are in the mountainous interior of Porto Rico and the five specimens known were swept from vegetation.

Holotype male, No. 24525, and allotype female, No. 24526, also paratypes, Nos. 24527 and 24528, in the collection of The American Museum of Natural History. A paratype female has been deposited in the U. S. National Museum.

Leptolycus heterocornis flavicollis, new variety

This variety agrees with the typical form, except that the color of the thorax and scutellum is yellow.

Aibonito, Porto Rico, July 1914, (H. G. Barber).

Holotype female, No. 24529, in the collection of The American Museum of Natural History.

LAMPYRIDÆ

The true Lampyridæ are nocturnal or crepuscular insects, whose life history beyond the obvious power of emitting an intermittent light is not well known. The larvæ have been described for a few species. These larvæ appear to be carnivorous and to live, in some cases for more than a year, in the soil or under vegetable débris. The adults are elongate, with comparatively soft elytra, short and robust legs, and long,

falciform, sharp-pointed mandibles. The light they emit from the posterior ventral segments, giving rise to their common name of "fireflies," has been the subject of many memoirs; an extended bibliography will be found in 'Coleopterorum Catalogus,' part 9, 1920, and recent additional contributions have appeared in 'Science.' The work of Herbert S. Barber of the U. S. National Museum, by which the life history of many species has been traced, is unfortunately still unpublished.

The determination of the sexes requires some care. The males in most species show an eighth segment, similar to the last segment in *Thonalmus*, and, furthermore, have the front of the head between the eyes concave, sometimes to the extent of a deep impression, while the front in the female is nearly flat.

The classification has received the attention of Castelnau, Lacordaire, Motschulsky, LeConte, Gorham, and in recent years of Ernest Olivier (grandson of G. A. Olivier), who, from 1885 to his death, wrote copiously on the subject and produced the essay in 'Genera Insectorum,' fasc. 53, upon which, with little alteration, we base the following key.

KEY TO SUBFAMILIES OF ANTILLEAN LAMPYRIDÆ

1. Head usually completely covered by the pronotum, neck never visible.....2.
   Head never completely covered by the pronotum; antennæ filiform, without branches.....PHOTURINÆ.
2. Antennæ simply filiform, without branches.....PHOTININÆ.
   Antennæ serrate or pectinate.....3.
3. Antennæ generally pectinate, not compressed, each joint being provided with projecting branches, sometimes merely with each joint excavated at apical end.....LAMPROCERINÆ.
   Antennæ compressed, serrate, the joints sometimes branching, but if so, by an extension of the whole substance of the joint.....LUCIDOTINÆ.

Lamprocerinæ

This subfamily, except for a few species described from Japan and Sumatra, appears to be American. In the West Indies it is represented, so far as known, by a single genus, which occurs in Cuba.

ALECTON Castelnau

1833, Ann. Soc. Ent. France, II, p. 135

The peculiarities of the antennæ in this genus were not sufficiently illustrated by E. Olivier; we think the figures we give show that the variety *improvisus*, described by that author, is entitled to specific rank. With a heretofore undescribed species in the Poey collection, we recognize three species for this genus, each with characteristic antennæ (Figs. 13, 14 to 16).

Alecton discoidalis Castelnau

Figures 14 and 15

Alecton discoidalis Castelnau, 1833, Ann. Soc. Ent. France, II, p. 135; 1840, 'Hist. nat. et icon. Coléop.,' I, p. 266. Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 83, Pl. vii, figs. 19 and 20. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 253. Gorham, 1898, Proc. Zoöl. Soc. London, p. 320. E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, Pl. i, fig. 5 (male antennæ); Rev. sci. du Bourbonnais, XXV, 1912, p. 19.

Alecton dorsalis Lacordaire, 1857, 'Hist. Nat. Insect. (Coléoptères),' IV, p. 320, Atlas, Pl. xliv, fig. 3.

Fig. 13. *Alecton flavum*, new species. Antennæ.
Fig. 14. *Alecton discoidalis* Castelnau, antennæ of male.
Fig. 15. *Alecton discoidalis* Castelnau, antennæ of female
Fig. 16. *Alecton improvisus* Ernest Olivier.

Head, pronotum, scutellum and body beneath dark yellow; antennæ of female (Fig. 15) eleven-jointed, yellow with the three apical joints brown; that of the male (Fig. 14) twelve-jointed, yellow; joints three to eleven each furnished beneath with a short wide branch, or eccentrically perfoliate. Elytra black; external margins with a yellow border which commences at about the basal third and extends to the apical suture. Length, 8 mm.

Cuba. Recorded from Cardenas by Gundlach. Two Cuban specimens in the Amer. Mus. Nat. Hist. collection are from Delcias, March 5, 1913, (S. Bevin), and Solidad, 10 miles west of Cienfuegos, (Barnum Brown).

Alecton improvisus E. Olivier

Figure 16

Alecton discoidalis var. *improvisus* Ernest Olivier, 1909, Bull. Soc. Ent. France, p. 221; 1911, Rev. sci du Bourbonnais, XXIV, p. 43; idem, 1912, p. 19.

Head, thorax, scutellum and body beneath, bright yellow. Antennæ of female twelve-jointed; the six apical joints dark brown; joints very strongly serrate; subpectinate. Elytra black; external margins with a pale yellow border, which commences quite close to the base and extends to the apical suture. Length, 8 mm.

This species, which was described by E. Olivier as a variety of *discoidalis*, may be separated from that species by its brighter yellow color,

by the antennæ having the six apical joints dark brown, and by the yellow marginal border which commences much nearer the humeral angle.

Described from Havana, Cuba, by E. Olivier. Two specimens in the Amer. Mus. Nat. Hist. collection are from seven kilom. north of Viñales, Cuba, September, collected by F. E. Lutz and C. W. Leng.

Alecton flavum, new species

Entirely pale yellow, above and beneath, the eyes only being black. Antennæ (Fig. 13) in the type, apparently a male, twelve-jointed, short, entirely yellow; second joint short; the succeeding joints excavated at the apex, each receiving the base of the next joint. Length, 9 mm.

Cuba, marked "1527, Poey coll."

Holotype male (?); Coll. Acad. Nat. Sci. Philadelphia.

This species resembles the two preceding in form, but it is entirely pale yellow. The antennæ are shorter, more excavated at the apex, and without projecting branches.

Lucidotinæ

This subfamily, represented on the American mainland by a few species of *Lucidota* with strongly compressed antennæ and a relatively broad body, is developed in Cuba, Porto Rico, and Hispaniola into a considerable number of species, which at one extreme approach *Alecton* in their broad outline, while at the other extreme they have a relatively narrow form combined with feebly serrate antennæ. Three genera may be separated by the form of the antennæ.

Antennæ strongly compressed, serrate. . . . *Lucidota.*
Antennæ feebly serrate. . . . . *Callopisma.*
Antennal joints narrow, oval in section. . . *Erythrolychnia.*

In addition to these three genera, several others have been proposed which seem to us too feebly defined to maintain, though *Pyropyga,* with antennæ more feebly compressed, has been used by Olivier for the species *incognita* from Grenada and St. Vincent. We believe that, with more material for study, an advantageous division of the species now placed in *Callopisma* might be made, but we refrain from doing so at present.

Lucidota Castelnau

1833, Ann. Soc. Ent. France, II, p. 136

A translation of Castelnau's description is as follows.

Antennæ almost as long as the body; eleven-jointed; the first joint large, the second short, all of the rest broad, much compressed, each provided in the males with a somewhat long branch. Labial palpi with last joint triangular; the maxillary

terminated by a very large joint pointed at the extremity. Tarsi with first joint as long as the two next united; the fourth bilobed; claws somewhat strong. Body elongate. Mandibles somewhat projecting. Head covered by the thorax, which is slightly angulate at the front. Scutellum triangular. Elytra elongate, almost parallel. Abdomen almost always with the two last segments luminous. Legs moderate; femur compressed.

The species which we have placed in this genus have the last ventral abdominal segment of the female broadly triangular and incised at the apex; the males have what looks like an eight segment, this segment being regarded by Ernest Olivier, 1911, Rev. sci. du Bourbonnais, XXIV, pp. 39–40, as part of the male genital apparatus. We also find that the males of the species have the antennæ more strongly serrate than the females, this character showing more plainly in *decorus* than in the other species.

On account of Castelnau's description of the antennal joints, "each provided in the males with a somewhat long branch," there is some doubt about the correctness of referring the following species to *Lucidota;* we have assumed that the above-mentioned stronger serration of the male antennæ is sufficient justification.

Excepting *incognita,* placed in *Pyropyga* by Ernest Olivier, none of the species of *Lucidota* occur in the Lesser Antilles.

Lucidota incognita E. Olivier

Photinus minutus Gorham, 1898, Proc. Zoöl. Soc. London, p. 319 (*nec* LeConte).
Pyropyga incognita Ernest Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 21.

The following is a free translation of Olivier's description: "Similar to *minuta* LeConte (of the U. S.) but larger, prothorax at most incompletely sulcate at base, and with two prominent transverse tubercles each side in front of the scutellum." The length is not given by Gorham, and E. Olivier merely says that it is larger than *minutus* LeConte.

Recorded by Gorham from "St. Vincent; windward and leeward side, Kingstown. Grenada; windward side, Grand Etang, Chantilly and La Force Estates; and leeward side, Mount Gay, Vendôme and St. George's Estates (H . H. Smith.)"

There are no specimens of this species from either of these islands at hand, but there are four male and two female specimens in the collection of the U. S. National Museum from Dominica, June and July, collected by H. W. Foote of the Yale Expedition, 1913, which have all the characters given in the meagre description by E. Olivier. The following is a description of the U. S. National Museum specimens.

Elongate, brown. Antennæ between one-third and one-half the length of the body, moderately compressed; joints from third onward subequal in length and barely noticeably serrate. Head somewhat prominent between the insertion of the antennæ. Pronotum moderately broadly rounded at apex; base sinuate, angles acute; sub-basal margin with an impressed row of coarse punctures, the row of coarser punctures continues around the whole submargin; disk dark brown, and with a slight transverse elevation on each side at base, the ends being nearly in contact at the base and extending along the submargin to the edges of the brown color; side margins transparent yellowish, the discal color extends to the apex but is more or less faded in color; pubescence sparse and very short. Scutellum elongate, triangular, apex truncate, angles rounded. Elytra brown, sides appearing slightly paler where they do not cover the body; granulate punctate; submargins with a row of medium coarse and somewhat closely placed impressed punctures; the whole elytra covered with short, sparse yellowish pubescence. Length, 4.5–6.25 mm.

Male.—Last dorsal segment slightly narrowed, broadly truncate, next to last ventral (seventh) segment slightly narrower than the preceding and with a broad /\-shaped incision at the apex; last (eighth) segment somewhat narrower than the preceding and broadly rounded at apex.

Female.—Last dorsal segment less broadly truncate than in the male. Last ventral slightly narrower than the preceding and gradually narrowing from the basal fourth and with a shallow /\-shaped incision at the apical end.

Lucidota decorus (Gemminger and Harold)

Rabopus roseicollis [preoccupied] Motschulsky, 1853, 'Etudes Entom.,' II, p. 42.
E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 34.
Photinus decorus Gemminger and Harold, 1869, 'Catalog. Coleop.,' VI, p. 1642.
Pygolampis decorus E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 35.

We believe two male and three female specimens in the collection of The American Museum of Natural History and one female specimen in the U. S. National Museum Collection to be this species. We think they should be placed in the genus *Lucidota* as the original description of *Rabopus* says "Antennæ filiform" and the specimens before us, especially the males, have the antennæ strongly serrate. The following is a translation of Motschulsky's description of *roseicollis*.

Elongate, oval, narrow, blackish; thorax red at the middle; yellowish at the margin; without spots; head, base of the antennæ, and the palpi, legs, and the whole border of the elytra yellowish white. Wings and last joint of the tarsi brownish. Eyes black. Length, 3 lines, width $\frac{4}{5}$ line.

The several male and female specimens which are in the collections before us may be known by the following description.

Elongate. Head and basal joint of antennæ varying in shade from yellowish to light brown, the remaining joints of the antennæ dark brown. Thorax somewhat broadly rounded in front; slightly sinuate at base; margin narrowly and feebly raised at front, more distinctly so at base; basal angles nearly right; disk longitudinally impressed at the middle; coarsely but not very closely punctured; sparsely pubes-

cent; color varying from a light to dark pink; apical and side margin yellowish, transparent, which in some specimens is more or less scattered with patches of the discal color. Elytra dark brown, completely margined with yellowish; not very coarsely but somewhat closely punctate; sparsely pubescent; apex separately rounded. Underside brown; apical abdominal segments more or less waxy white. Legs yellowish to light brown, fourth and sometimes all of the tarsal joints slightly darker.

Male.—Antennæ about as long as the body; somewhat strongly serrate. Dorsal abdominal segments brown; last segment slightly narrowed; broadly and squarely truncate at apex. Last ventral (eighth) segment somewhat abruptly narrowed and pointed at apex. Length, 6–7 mm.

Female.—Antennæ a little more than one-half the length of the body; slightly serrate. Dorsal abdominal segments brown; apex of last segment slightly paler gradually narrowing and narrowly truncate at apex. Last ventral segment triangular and with a deep /\-shaped incision at apex. Length, 7.5–9.5 mm.

These are very similar in color to specimens from Cuba which we believe to be *Lucidota miniatocollis*.

The Motschulsky species was described from Porto Rico, but the Gemminger and Harold Catalogue and 'Genera Insectorum' give Santo Domingo as the locality. The specimens from which our description was made are from Porto Rico: two females and one male from Naguabo, March, (F. E. Lutz); one male, Coamo Springs, January, and one female, near Corozol Cave, January, (H. E. Crampton), Coll. Amer. Mus. Nat. Hist.; also one female, Bayamon, January, (Aug. Busck), Coll. U. S. Nat. Mus.

Lucidota miniatocollis (Chevrolat)

Lychnuris miniatocollis Chevrolat, 1858, Rev. et. Mag. de Zoöl., (2) X, p. 209.
Lucidota miniatocollis Gorham, 1898, Proc. Zoöl. Soc. London, p. 320.
Callopisma miniatocollis E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 20.

There are in the collection of The American Museum of Natural History two specimens which do not agree in every detail with Chevrolat's original description but we believe them to be the above species. The following is a description of the specimens at hand.

Male.—Antennæ black, not quite as long as the body, plainly but not strongly serrate. Front of head blackish brown; mouth-parts yellow; apex of mandibles brown. Disk of pronotum longitudinally impressed, bright pink, not coarsely or very closely punctate, sparsely clothed with whitish yellow pubescence; side and front margin transparent, yellowish; basal margin broadly sinuate, angles slightly acute; sub-basal margin with a confused row of coarser punctures. Scutellum yellow with a pink tinge, moderately coarsely but not closely punctate. Elytra brownish black, excepting the side margin which are bordered from humeri to the apical third with a dirty white color; moderately finely and closely granulate-punctate; sub-marginal area with a row of coarser indented punctures which extend from the humeri

around the apex to the scutellum; sparsely clothed with short yellowish pubescence. Dorsal segments of abdomen brown with the apex of last segment white; last segment broadly sinuately emarginate at the apex. Pro- and mesosternum pinkish; remainder of underside, excepting the last two abdominal segments, brown; last two segments white; last segment (eighth) triangularly pointed. Femora yellow, shading to brown at apex tibiæ and tarsi darker. Length, 7.5 mm.

Female.—Antennæ about one-half as long as the body, flattened, very feebly serrate, black, basal joints infuscate. Front of head blackish brown; mouth-parts yellowish; apex of mandibles darker. Disk of pronotum slightly impressed, dull pink, not coarsely or very closely punctate; pubescence very sparse; side and front margins transparent, yellowish; basal margin broadly sinuate, angles slightly acute; sub-basal margin with a confused row of coarser punctures. Scutellum yellow, tinged with pink, somewhat coarsely but not closely punctured. Elytra lighter brown than in the male; side and sutural margins dirty white, the marginal color is disconnected at the apex; closely granulate punctate; submarginal row of punctures broken and indistinct; very sparsely clothed with yellowish pubescence. Dorsal segments of abdomen, excepting the last, dark brown; last segment pale yellow, narrowly emarginate. Pro- and apex of mesosternum, pinkish, remainder of the underside, excepting the last abdominal segment, brown, with the central part of the abdominal segments paler; last segment very pale yellow and with a very shallow /\-shaped incision at its apex. Length, 7.25 mm.

The two specimens from which the above description was made were collected by Dr. Chas. T. Ramsden at Rio Seco, San Carlos Estate, Guantanamo, Cuba (male, February 9, 1915; female, May 9, 1914). There is in the collection of Acad. Nat. Sci. of Philadelphia a female specimen which we believe belongs to this species, but it is in such poor condition that we are unable to see some of the important characters.

The locality given by Chevrolat in the original description is simply "Cuba."

Lucidota marginipennis, new species

Elongate. Head and antennæ brownish black. Pronotum somewhat narrowly rounded at front (more narrowly than in the other two species); outer and basal margins slightly raised; disk convex with a longitudinal impressed line from the base to about the middle; apical half coarsely and closely punctate; basal half moderately, finely and somewhat closely punctate; sub-basal margin with a row of coarse punctures; sparsely pubescent at sides; very dark brown nearly black, with basal, or finely punctured, portion somewhat broadly bordered at the sides with pink; margins transparent yellowish, apical portion much narrower than at sides. Scutellum yellow, brown in some specimens. Elytra blackish brown, side and sutural margins bordered with dirty white, the marginal border does not extend entirely around the apex; granulate punctate. Underside blackish brown. Legs light to dark brown; coxæ, base of femora, base of tibiæ and, sometimes, basal part of tarsal joints paler than the apical parts.

Male.—Antennæ, from third joint on, serrate. Apical dorsal abdominal segment bordered at sides with lighter color, broadly truncate; angles rounded. Next

to last (seventh) ventral abdominal segment brown at the middle, sides paler, yellowish; last (eighth) segment entirely brown. Length, 7.5–8 mm.

Female.—Antennæ slightly serrate. Apical dorsal abdominal segment as in the male. Last ventral abdominal segment yellowish white, bordered at apex with brown, apex suddenly narrowed and with a medium /\-shaped incision at the apical end. Length, 8.5 mm.

Holotype male, No. 24592, allotype female, No. 24593, also one male and one female paratypes, No. 24594, all from Aibonito, Porto Rico, June, (H. G. Barber and F. E. Watson); Coll. Amer. Mus. Nat. Hist.

Callopisma Motschulsky

1853, Etudes Entomologiques, I, p. 42

The type assigned to this genus by Motschulsky is *rufa* G. A. Olivier, having the broad form of *Alecton* and long, compressed, serrate antennæ. Many of the species since assigned to the genus are not strictly congeneric; one of these, *miniatocollis*, we have removed to *Lucidota* and perhaps still more should be removed. They may be separated by the following key.

Key to the Species of *Callopisma*

1. Elytra unicolorous.....2.
   Elytra bicolored.....5.
2. Elytra black without violet reflection.....3.
   Elytra brownish black with a strong violet reflection.....*janthinipennis.*
3. Thorax reddish yellow with slightly paler margin.....4.
   Thorax yellow, without paler margin; mesosternum and abdomen (apex excepted) black.....*demissa.*
4. Body beneath rust-red; tibiæ and tarsi blackish.....*militaris.*
   Body beneath flavous, ventral abdominal segments sometimes more or less marked with blackish; tibiæ and tarsi black or dark brown....*flavilabris.*
5. Elytra black, with with pale or yellow margin.....6.
   Elytra yellow or orange, at least in basal part.....7.
6. Elytra margined with yellow on the base, basal third of the suture and slightly beyond the basal half of the lateral margin.....*bellicosa.*
7. Elytra parallel or subparallel sided.....8.
   Elytra broadly oval.....11.
8. Elytra with not more than basal half yellow.....9.
   Elytra yellow for nearly two-thirds from base; legs yellow, tarsi dark.*postica.*
9. Yellow portion covering less than basal half of elytra.....10.
   Yellow portion extending over approximately the basal half of elytra. *dimidiatipennis.*
10. Yellow portion extending over basal third or less of elytra, small species 4.5 to 8 mm.....*adjuncta.*
    Yellow portion extending over basal third or more of elytra, large species, 11 to 12 mm.....*borencona.*
11. Antennæ short, about half as long as body.....12.
    Antennæ nearly as long as body; dark portion of elytra confined to approximately apical third; tibiæ and tarsi black.....*ramsdeni.*

12. Body very broad, about two-thirds, or more, as broad as long.....13.
    Body not over one-half as wide as long; dark portion of the elytra variable, sometimes reduced to a small spot on the apex, generally confined to the apical half; or even with a basal spot (var. *humeralis*).....*rufa*.
13. Color pale red, apical third of elytra and antennæ black.....*mariposa*.
    Color reddish yellow, apical half of elytra and antennæ black..*emarginata*.

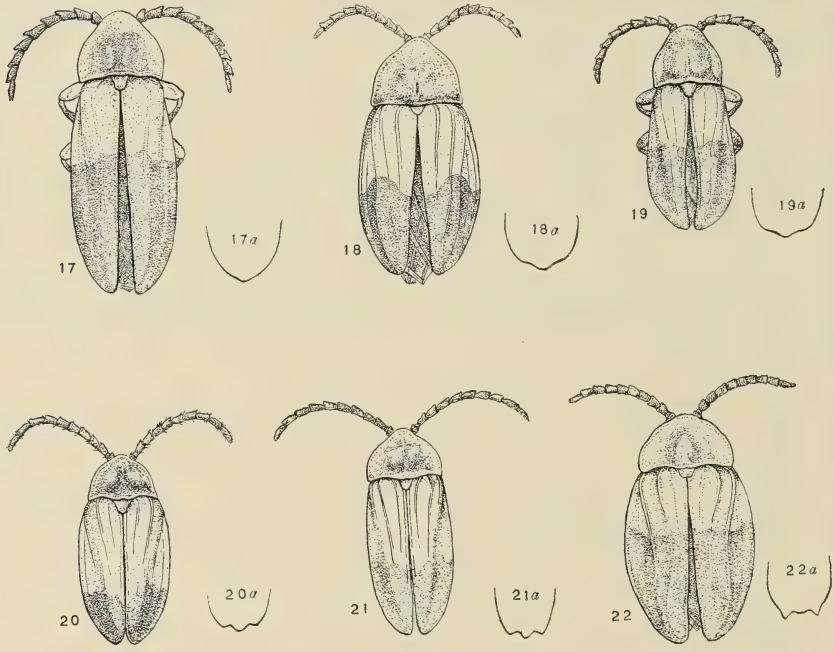


Fig. 17. *Callopisma borencona*, new species.
Fig. 17*a*. *Callopisma borencona*, pygidium of male.
Fig. 18. *Callopisma rufa* (Olivier).
Fig. 18*a*. *Callopisma rufa*, pygidium of male.
Fig. 19. *Callopisma dimidiatipennis* (Jacquelin Duval).
Fig. 19*a*. *Callopisma dimidiatipennis*, pygidium of male.
Fig. 20. *Callopisma mariposa*, new species.
Fig. 20*a*. *Callopisma mariposa*, pygidium of male.
Fig. 21. *Callopisma ramsdeni*, new species.
Fig. 21*a*. *Callopisma ramsdeni*, pygidium of male.
Fig. 22. *Callopisma emarginata*, new species.
Fig. 22*a*. *Callopisma emarginata*, pygidium of male.

Callopisma borencona, new species

Figures 17 and 17*a*

Elongate; yellow, with apical two-thirds of elytra, tibiæ and antennæ black. Antennæ of male more than half as long as body, serrate, pubescent, strongly compressed from the third joint; similar in the female but less than half as long as body. The apex of the third joint in the male is very oblique and the outer angle is somewhat prolonged. Head prolonged into a short beak. Prothorax rounded in front, projecting over the head, feebly punctured and channeled, somewhat rosy on the disk.

Pygidium (Fig. 17*a*) of male rounded, very feebly sinuate each side, that of female deeply arcuately emarginate. Length, 11–12 mm.

Holotype male, No. 24537, Mayaguez, Porto Rico, May, (R. H. Van Zwaluwenburg); allotype female, No. 24538, Adjuntas, Porto Rico, June, (Lutz and Mutchler); and two female paratypes, Nos. 24539, Martin Peña, Porto Rico, January, (H. E. Crampton); Coll. Amer. Mus. Nat. Hist.

Resembles *C. adjuncta* E. Olivier from Cuba, but is much larger and the apical black color of elytra does not extend as far toward the base.

Callopisma rufa (G. A. Olivier)

Figures 18 and 18*a*

Lampyris rufa G. A. Olivier, 1790, 'Entomologie,' II, No. 28, p. 28, Pl. III, fig. 30.
Callopisma rufa Motschulsky, 1853, 'Etudes Entom.,' I, p. 42. E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 19.
Photinus rufus Gorham, 1880, Trans. Ent. Soc. London, p. 23; 1898, Proc. Zoöl. Soc. London, p. 320.
Callopisma rufa var. *humeralis* E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 19.

Orange yellow. Elytra black at the apex and sometimes at the humeri, humeral spots when present sometimes reduced to nebulous clouds. Last abdominal segment different in the sexes. The pygidium (Fig. 18*a*) of the male is more or less rounded at the apex, and the last ventral segment truncate. The female pygidium is elongate, triangular or conical with the last ventral segment triangular. Length, 8.5–10 mm.

The specimens with a black spot on the base of the elytra have been called variety *humeralis* but we have not recognized them as such, as this spot has a tendency to disappear in some specimens. This species resembles *Erythrolychnia fulgidus* (G. A. Olivier), but differs in being generally smaller. The antennal joints are wider. The pronotum is longer and angulated instead of rounded in front. The apical black spot on the elytra has a faint purplish reflection, this spot being dull black in *E. fulgidus*. The color of the last ventral abdominal segment is red; this segment is black in *E. fulgidus*.

Described from Haiti. We have seen one specimen from Port au Prince, Haiti; Coll. U. S. Nat. Mus. Three, Port au Prince, Haiti, (R. J. Crew); Coll. H. F. Wickham. Two of the latter are what has been called variety *humeralis*.

Motschulsky says the species also occurs in St. Thomas.

Callopisma dimidiatipennis (Jacquelin Duval)

Figures 19 and 19*a*

Lychnuris dimidiatipennis Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 84. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 251.

Lucidota dimidiatipennis GORHAM, 1898, Proc. Zoöl. Soc. London, p. 320.
Callopisma dimidiatipennis E. OLIVIER, 1912, Rev. sci. du Bourbonnais, XXV, p. 19.

Coloration similar to that of *C. ruja*, of which it has been incorrectly, we think, called a synonym; it is more narrow, the antennal joints are more dilated, and the apical black spot extends beyond the middle of the elytra. The pygidium (Fig. 19*a*) of the male is triangularly emarginate; truncate in the female. Length, 4.5–8 mm. In the specimens examined by us, there has been none smaller than 6 mm.

Recorded from Cardenas and Matanzas, Cuba, by Gundlach and from Porto Rico by E. Olivier. We have seen specimens from the following Cuban localities. Coll. U. S. Nat. Mus.: Baracoa, (Aug. Busck); Havana and Guantanamo, (C. F. Baker). Coll. Amer. Mus. Nat. Hist.: La Victoria, Guantanamo, May, (Chas. T. Ramsden).

The National Museum specimens were sent to E. Olivier but were returned by him unidentified. We believe they are *dimidiatipennis*.

Callopisma mariposa, new species

Figures 20 and 20*a*

Male.—Broadly oval; pale red with only the antennæ and apical fifth of elytra black. Antennæ two-thirds as long as body; joints three to eleven, strongly compressed, pubescent, broad, and feebly serrate. Head deeply sunk in the thorax but slightly prolonged beyond the moderate eyes. Thorax rounded in front, wider than long, surface minutely tuberculate. Elytra together almost as broad as long, closely punctate, with strongly reflexed epipleuræ, rapidly narrowing but reaching the apex. Legs strongly compressed, yellowish red, the tarsi scarcely darker, joints short, the fourth deeply emarginate. Pygidium (Fig. 20*a*) rounded at apex, strongly sinuate each side, obtusely elevated through the median line. Length, 7 mm.

Female.—Unknown.

Hispaniola: Dominican Republic.

Holotype male, No. 24527, from Sanchez, May 11, 1915, (F. E. Watson), and paratype male, No. 24528, from Santo Domingo, April 1, 1913, in Coll. Amer. Mus. Nat. Hist.

This species indicates a different genus and by its broad form looks very different from the following species, but is provisionally attached to *Callopisma* until more material permits further study.

Callopisma ramsdeni, new species

Figures 21 and 21*a*

Male.—Broadly oval; reddish yellow with the apical third of elytra, margin of ventral abdominal segments, tibiæ and antennæ black. Antennæ nearly as long as the body; joints three to eight strongly compressed, feebly serrate, and very broad, joints nine to eleven becoming gradually narrower. Head prolonged in a short, subtriangular beak. Thorax broadly rounded in front, concealing the head; coarsely punctate around the margin, more finely on the disk which is channeled. Elytra moderately punctured, very obsoletely costate; the apical third black with a very

faint violet lustre, the black area arcuately limited in front and extending further on the margin than the suture. Legs strongly compressed, black. Pygidium (Fig. 21*a*) biemarginate or bisinutate. Length, 6 mm.

Female.—Unknown.

Cuba: Belona, Guantanamo and La Maya.

Holotype male, No. 24529, from Belona, Guantanamo, June 16, 1914, and five male paratypes, No. 24530, Belona, Guantanamo, June, and La Maya, July, (Chas. T. Ramsden); Coll. Amer. Mus. Nat. Hist. Two male paratypes from La Maya, Coll. Chas. T. Ramsden. A specimen (Poey Coll. No. 711) in Coll. Acad. Nat. Sci. Philadelphia seems to be identical.

This species is dedicated to Dr. Chas. T. Ramsden in recognition of his many years of study and his success in making known the insect fauna of Cuba.

Callopisma emarginata, new species

Figures 22 and 22*a*

Broadly oval; reddish yellow, apical half of elytra, antennæ and tibiæ, black. Antennæ half as long as body; third and following joints strongly compressed, feebly serrate and densely pubescent. Head prolonged and narrowed in front. Palpi large, dark, four-jointed. Thorax wider than long, rounded in front, rosy on disk, coarsely punctured around the margin, feebly on disk; median channel very short and broad. Elytra closely punctate; apical half black, with a strong blue reflection. Legs compressed as usual. Pygidium (Fig. 22*a*) emarginate, bottom of emargination strongly bisinuate in the male, truncate in the female. Length, 8–9 mm.

Described from Porto Rico.

Holotype male, No. 24531, and allotype female, No. 24532, from Mayaguez, June and July, (Lutz and Mutchler). Five male paratypes, Nos. 24533–24536 inclusive, from Mayaguez, April and July, (R. H. Van Zwaluwenburg); Mayaguez, June and July, and Adjuntas, June, (Lutz and Mutchler); Rio Blanco Valley, January, (H. E. Crampton). These are in Coll. Amer. Mus. Nat. Hist. One male paratype from Utuado, January, (Aug. Busck), in Coll. U. S. Nat. Mus.

By its shorter antennæ, this species loses one of the characters that separate *Callopisma* from *Photinus*. In coloration it resembles *C. dimidiatipennis* but is much broader, with shorter antennæ and different pygidium. The paratype from Utuado was sent to E. Olivier for determination but was returned by him unnamed.

Callopisma adjuncta (E. Olivier)

Lychnuris adjuncta E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 90.
Callopisma adjuncta E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 19.

Similar in form and coloration to *C. ruja*, but the apical dark part of the elytra extends far beyond the middle so that only a basal band remains orange. Length, 7 mm.

Described from Cuba. We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: Cayamas, Cuba, May, (E. A. Schwarz). Coll. Acad. Nat. Sci. Philadelphia: Cuba, (Poey Coll.).

Callopisma postica (E. Olivier)

Lychnuris postica E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 90.
Callopisma postica E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 20.

Very narrow, elongate; entirely yellowish red, excepting a black spot at apex of elytra, covering about the apical third, and the brownish antennæ and tarsi. Length, 6.5 mm.

The pygidium in the specimens before us, which appear to be males, is concealed by the wings; as far as it can be seen, it seems to be simply rounded.

Described from Santo Domingo. We have seen specimens from San Lorenzo and Sanchez, Dominican Republic, June, (F. E. Watson), Coll. Amer. Mus. Nat. Hist.

Callopisma bellicosa (E. Olivier)

Lychnuris bellicosa E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 91.
Callopisma bellicosa E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 20.

Pronotum and scutellum orange-yellow. Antennæ black, with the first joint orange-yellow at the side. Elytra black, with about the basal third of the suture, the basal margin and the external margin narrowly bordered with orange-yellow. The ventral surface, the femora, a very small part of the base and the inner side of the tibiæ are orange-yellow; the remaining portion of the tibiæ and the tarsi are dark brown. The pygidium of the male is rounded; of the female, acutely triangular. Length, 9–10 mm.

The first joint of the antennæ in the specimens before us is yellowish at the side and not red above, as described by E. Olivier.

Described from Cuba. We have seen specimens from Coll. Acad. Nat. Sci. Philadelphia: Cuba, female, (Poey Coll. No. 1715). Coll. Amer. Mus. Nat. Hist.: Viñales, Cuba, September, (Lutz and Leng).

Callopisma demissa (E. Olivier)

Lychnuris demissa E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 90.
Callopisma demissa E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 20.

Prothorax yellow, without paler margin. Elytra black; narrower and more nearly parallel than *flavilabris*, and with the basal angles of the prothorax less prominent. Pygidium rounded in the female, male not seen. Length, 6.5 mm.

Described from Cuba. We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: Cayamas, Cuba, June, (E. A. Schwarz). Coll. Acad. Nat. Sci. Philadelphia: Cuba, (Poey Coll. No. 362). Coll. Carnegie Mus.: Isle of Pines, November, (Link).

Callopisma flavilabris (E. Olivier)

Lychnuris flavilabris E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 90.
Callopisma flavilabris E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 20.

Prothorax yellow with slightly paler margin. Elytra black. Body beneath flavous, with ventral abdominal segments in some specimens more or less blackish. Pygidium feebly truncate in the male. Length, 7 mm.

Described from Cuba, from which island we have seen specimens, (Poey Coll. No. 1767 and No. 1715) Coll. Acad. Nat. Sci. Philadelphia.

Callopisma militaris (E. Olivier)

Lychnuris militaris E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 91.
Callopisma militaris E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 21.
Identical with *C. flavilabris* except as stated in the key. Length, 8 mm.

With more material for study, we would perhaps unite *flavilabris* and *militaris* under the former name; and it may prove that both are the males of *demissa*.

Described from Cuba. We have seen specimens from Guantanamo, Cuba, June, (Chas. T. Rasmden), Coll. Amer. Mus. Nat. Hist.

Callopisma janthinipennis (Jacquelin Duval)

Lychnuris janthinipennis Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 83. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), p. 251.
Lucidota janthinipennis Gorham, 1898, Proc. Zoöl. Soc. London, p. 320.
Callopisma janthipennis E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 21. (The specific name is here misspelled.)
Very small. Prothorax yellow with a small brown spot. Elytra brown with a violet reflection. Length, 3.7 mm.

Described by Duval from one specimen in the Guérin-Méneville collection from Cuba. Recorded from Bayamo, Cuba, by Gundlach, (1894). We have seen two specimens from Cayamas, Cuba, May, (E. A. Schwarz), and one specimen from Havana, Cuba, (Baker), Coll. U. S. Nat. Mus.

There is in the Amer. Mus. collection one male specimen from Guantanamo, Cuba, which is very similar to this species but the thorax is pinkish red with approximately the apical third yellow. The antennæ are more strongly serrate. The elytra are dark brown, but the violet reflection is not as pronounced as in the National Museum specimens which were determined by E. Olivier as *janthinipennis*.

In concluding our study of *Callopisma*, we regret that we were unable to see longer series of certain species, for conclusions that we suspected could not be sufficiently verified.

Erythrolychnia Motschulsky

1853, 'Etudes Entom.,' I, p. 29

In our study of the species contained in the genus *Photinus*, we could not satisfactorily place *fulgidus* and several somewhat closely allied species in that genus, one difference which we considered of importance being that the eighth ventral abdominal segment did not appear in the males. We have also extracted the male genital apparatus from specimens which do not show the eighth ventral abdominal segment and from specimens of *Photinus pallens* and other well-known species of *Photinus*. The difference in structure is very notable, as will be seen in figures 23 and 24. We consider these differences sufficient reasons for removing *fulgidus* and its allied species from the genus *Photinus*. We have, therefore, restored the genus *Erythrolychnia* Motschulsky, the type species of which is *fulgidus* (*dimidiatipennis*), and have included under this heading the allied species, *bipartitus*, *quinquenotatus*, and two new species which we are describing in this paper.

The following is a translation of Motschulsky's description of the genus.

Fig. 23. *Erythrolychnia quinquenotatus* (Castelnau), male genital tube.

Fig. 24. *Photinus pallens* (Fabricius), male genital tube.

Shape oval; depressed. Pronotum halfmoon-shaped, a little projecting, margined, its posterior angles prominent, sharp. Antennæ half the length of the body, filiform, thinner towards the apex; first joint as long as the second and third together; the fourth and the following of equal length and a little shorter. Three distinct veins on the elytra. First joint of the tarsi nearly as long as the two following together, the fourth shorter, bilobed. Lobes projecting, but obtuse. Last segment of the upper and underside of the abdomen triangular, the abdomen emarginate at the apex. Type, *Erythrolychnia dimidiatipennis* Mannerheim. From Sto. Domingo in the Antilles.

This genus has been placed in synonymy by previous authors and was treated as a synonym of the genus *Pygolampis* by E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 24.

The following additional notes on characters not mentioned in the original description will be of some assistance to the student.

Thorax strongly rounded, large, completely concealing the head. The elytra broad, each elytron three times as long as broad. Antennæ eleven-jointed; joints three to eleven feebly compressed, narrowly oval in section; second joint short, about one-fourth as long as adjacent joints; eleventh joint narrower than preceding, fusiform; all densely pubescent. Labial palpi three-jointed; last joint large triangular. Maxillary palpi four-jointed; last joint oval, pointed. Eyes large, globular, finely granulate. Coxæ contiguous. Trochanters triangular, articulating with the femora externally, somewhat intermediate in this respect between Lycidæ and Lampyridæ. Legs compressed as usual; the tarsi stout with fourth joint deeply bilobed. Abdomen

with seven segments; with slight evidence of luminous character on third from last segment; the eighth ventral segment of the male (or part of genital apparatus) does not appear in the species of this genus.

Erythrolychnia fulgidus (G. A. Olivier)

Figure 25

Lampyris fulgida G. A. Olivier, 1790, 'Entomologie,' II, No. 28, p. 16, Pl. II, fig. 9.
Erythrolychnia dimidiatipennis Motschulsky, 1853, 'Etudes Entom.,' p. 29; idem., 1854, p. 5.
Pygolampis fulgidus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 24.

Reddish testaceous. Head black. Pronotum in some specimens with two small, almost contiguous, black spots on the disk. Scutellum triangular. Elytra with black on the apical half. Last two ventral abdominal segments black, bordered with testaceous on the lateral edges; last ventral triangular in both sexes; emarginate at the apex in the female. Length, 10 mm.

In some specimens two small, almost contiguous, black spots appear on the middle of the disk of the pronotum, these are lacking in G. A. Olivier's figure of the species but are mentioned by Motschulsky (1854).

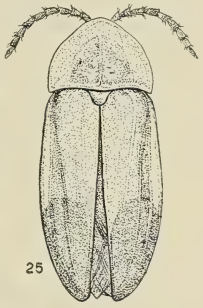


Fig. 25. *Erythrolychnia fulgidus* (Olivier).

Motschulsky (1853) gives *dimidiatipennis* as the type of the *Erythrolychnia*, and this same author (1854) says "a second species of this genus appears to be *Lamp. fulgida* Ol. of the same locality." The former species is considered a synonym of *fulgidus* by E. Olivier.

Described from Santo Domingo by G. A. Olivier. We have before us three specimens from San Francisco Mts., Dominican Republic, and one with no more definite locality than "St. Domingo," Coll. U. S. Nat. Mus. All were determined as *Pygolampis fulgidus* by E. Olivier in 1911, which was previous to his description of *bipartitus*. We have concluded that only two of the specimens from San Francisco Mts. are *fulgidus*, the others being *bipartitus* described by E. Olivier, in 1912. There is also one specimen from Puerto Plata, Dominican Republic, March, in thee American Museum collection, which we have determined as *E. fulgidus*.

Erythrolychnia bipartitus (E. Olivier)

Pygolampis bipartitus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 24.

Red. Head black or brown. Antennæ black with first three joints piceous. Elytra with black apical spot, covering one-third of their length. The last two ventral abdominal segments and base of pygidium black. Tarsi piceous. Prothorax short, rounded in front, cribrately punctate at margin; disk shining. Length, 9–11 mm.

Described from Santo Domingo. We have seen specimens from Coll. U. S. Nat. Mus., San Francisco Mts., September, (Aug. Busck); and Coll. Amer. Mus. Nat. Hist., Puerto Plata, January or February. Both of the above localities are in the Dominican Republic.

Erythrolychnia olivieri, new species

Reddish to yellowish brown. Antennæ blackish brown. Pronotum broadly rounded in front; basal angles slightly acute; margin broadly bisinuate; frontal part, (reaching well up on the disk and sides) coarsely and closely punctate; basal part of disk with an irregular callous-like spot which is more finely punctate; middle of pronotum with a slight carina, more noticeable in the female. Elytra somewhat coarsely and closely granulate punctate; each with a black spot at the base, reaching back to a little more than twice the length of the scutellum, but only touching the scutellar area at the basal part; also with a black spot at the apex which covers about the apical third, the apical spots are more advanced on the disk on the suture or sides; disk with two carina which do not reach either the base or the apex. Underside of male with last two abdominal segments dark. The female has the last three segments dark. Length, 9 mm.

Holotype male, No. 24588, Higueral, Dominican Republic, (E. G. Smyth), Coll. Amer. Mus. Nat Hist.; allotype female, San Francisco Mts., Dominican Republic, September, (Aug. Busck), Coll. U. S. Nat. Mus.

The female specimen which we have made the allotype was determined as "*Pygolampis 5-notatus* var." by E. Olivier, but we believe it to be deserving of specific rank. There are no markings on the pronotum and the basal markings are longer and of a deeper black than in *quinquenotatus*. The apical black markings are very similar to *bipartitus*.

Erythrolychnia quinquenotatus (Castelnau)

Photinus quinquenotatus Castelnau, 1840, 'Hist. nat. et icon. Coléop.,' I p. 269.
Pygolampis quinquenotatus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 24.

Red. Pronotum with a black spot on disk. Elytra with a black spot near the humerus and another near the apex, the apical ones are sometimes reduced to nebulous clouds. Length, 10–12.5 mm.

Type locality: Port au Prince, Haiti. We have seen specimens from the following localities. Coll. H. F. Wickham: Port au Prince, Haiti, (R. J. Crew). Coll. Amer. Mus. Nat. Hist.: Diquini, Haiti, (Wm. M. Mann).

Erythrolychnia albopalpis, new species

Male.—Broadly oval. Dull yellow, except for a black area on the apex of each elytron, starting from a point on the lateral margin of the elytra about two-thirds of the distance from the base, the anterior border of each black area is /\-shaped near the lateral margin and then runs obliquely back to a point on the sutural margin near the apex. Antennæ and palpi brown. Antennæ with the two basal joints paler and the

basal part of all of the joints pale. Apical end of each joint of palpi waxy white. Pronotum with front and sides coarsely punctate; base of disk more finely punctate. Elytra somewhat coarsely and closely punctate and sparsely pubescent. Femora yellow; tibiæ and tarsi slightly darker, which is caused in part by darker pubescence. Length, 9 mm.

Female.—Unknown.

Holotype, No. 24518, Saona, Haiti, July or August; Coll. Amer. Mus. Nat. Hist.

Photininæ

This subfamily includes the largest number of species and presents the greatest difficulty in its classification. The genus *Photinus*, from which it derives its subfamily name, includes 143 species, of which about 20 per cent were separated without any definite characters by Motschulsky under the name *Pygolampis*. This name was used by E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, in his 'Contribution à la faune entomologique des Antilles,' but we have rejected the unsatisfactory attempts to divide this genus and have retained the name *Photinus* for the West Indian species. A further account of the different genera will be found under the generic headings. We divide the genera as follows.

Key to West Indian Genera of Photininæ

1. Body oval.....2.
   Body oblong.....3.
2. Eyes in male very large, often contiguous; pronotum with two glassy spots. *Cratomorphus.*
   Eyes not contiguous, glassy spots lacking.....*Aspisoma.*
3. Pronotum prolonged at side, angulate at apex.....*Pyractomena.*
   Pronotum rounded at apex, not distinctly angulate.....*Photinus.*

Cratomorphus is a Central and South American genus erected in 1853. It occurs in Trinidad but, so far as we know, not in the West Indies proper. The description of *Lampyris dorsalis* Gyllenhal (referred to *Cratomorphus* by Motschulsky) has been included in this paper, as Gyllenhal in his original description gives "Insula Bartholemy" as the type locality. This species may be West Indian but unrecognized because erroneous reference to the genus *Cratomorphus*.

We have not included the genus *Macrolapmis* in this paper. Our record, in the 'Preliminary List of the Coleoptera of the West Indes,' of *M. perelegans* is based merely on the citation of the locality "Antigua" in 'Biologia Centrali Americana,' (Coleoptera) III, part 2, p. 40, and we have now decided to omit the species until further proofs of it being West Indian are obtainable. The genus is from Central and South America.

The genus *Heterophotinus*, which was erected by E. Olivier for a species in which the elytra of the female are shorter than the abdomen, has been disregarded by us, there being, as far as we can see, no other character to separate the species from *Photinus;* we find that there are also other species in the genus *Photinus* which have the elytra of the female shorter than the abdomen.

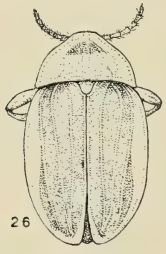
Aspisoma Castelnau

1833, Ann. Soc. Ent. France, II, p. 145

This genus, 55 species of which occur in South and Central America, contains a few species in the most southern Antillean islands; these may be separated as follows.

Key to West Indian Species of *Aspisoma*

1. Oblong shield-shaped; pronotum yellow or brownish yellow, with darker markings.....2.
   Oblong oval; pronotum ochraceous with an indistinct darker spot at middle of disk, bisinuate in outline, and in some specimens with two very obscure spots at middle of base; elytra pitchy black, sides and suture with entire margin.....*superciliosum.*
2. Outer margin of the elytra with a rectangular yellowish spot near the humerus.3.
   Elytra margined on the sides and suture with yellow, margin widest at base of lateral margin, and enclosing two brown spots, one near the humerus, the other near the middle.....*insperatum.*
3. Disk of elytra with three, more or less well-marked, fine, yellow lines..*ignitum.*
   [Three yellow lines better defined, extending almost throughout the length of the elytra, and a fourth starting from the humerus and coalescing with and extending beyond the marginal spot.....var. *polyzonum.*]



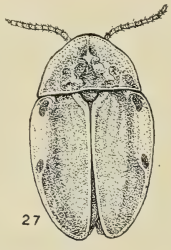


Fig. 26. *Aspisoma superciliosum* Gorham.
Fig. 27. *Aspisoma insperatum* Ernest Olivier.

Aspisoma superciliosum (Gorham)

Figure 26

Aspidosoma superciliosum Gorham, 1898, Proc. Zoöl. Soc. London, p. 318.
Aspisoma superciliosum E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 23.

Pronotum yellow, with three small brown spots, one on the disc and two approximate (sometimes wanting) above the scutellum. Elytra brown, with the margin, broadly, and the suture, narrowly, bordered with yellow. Length, 7–8 mm.

Described from St. Vincent; Grenada, leeward and windward sides; and Union Island, Grenadines, (H. H. Smith). Coll. British Mus.

Our figure is drawn from a cotype specimen kindly loaned by the British Museum.

Aspisoma insperatum (E. Olivier)

Figure 27

Aspidosoma ignitum (Linnæus) Gorham, 1898, Proc. Zoöl. Soc. London, p. 318.
Aspisoma insperatum E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 22.

Leathery brown. Pronotum testaceous with a sinuous brown spot reaching the base but not passing beyond the middle; also with darkish spot in each basal angle. Elytra with the lateral margins bordered with yellow, broadly as far as the middle, narrowly beyond it to the suture, within the yellow border are two brown spots, one on the humeral callus, the other a little beyond the middle; there are also, in some specimens, traces of longitudinal pale lines, not prominent, on the disk. Tibiæ and basal half of femora testaceous. Length, 11–12 mm.

Recorded as *ignitum* Linnæus by Gorham from Kingstown, St. Vincent; Grenada, leeward and windward sides; Union Island and Mustique Island, Grenadines, (H. H. Smith). We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: St. Lucia ("Ac. 21, 699, U. S. F. C."). Coll. Brit. Mus.: Mount Gay Estate, leeward side, Grenada, (H. H. Smith); Castries, St. Lucia.

Our figure is drawn from a specimen kindly loaned by the U. S. National Museum.

Aspisoma ignitum (Linnæus)

Lampyris ignita Linnæus, 1767, 'Syst. Natura,' I, part 2, p. 645. De Geer, 1774, 'Mém. pour servir à l'histoire Insect.,' IV, p. 49, (French edition), p. 29, Pl. xvii, fig. 2, (German translation by Goeze, 1781, p. 29, Pl. xvii, fig. 2). Fabricius, 1775, 'Syst. Entom.,' p. 201. G. A. Olivier, 1790, 'Entomologie,' II, No. 28, p. 15, Pl. i, fig. 7. Castelnau, 1840, 'Hist. nat. et icon. Coléop.,' I, p. 269.
Aspisoma polyzona Chevrolat, 1834, 'Coléoptères du Mexique Cent.,' I, fasc. 3, No. 51.
Myctophanes ignita Motschulsky, 1853, 'Etudes Entom.,' II, p. 11.
Aspidosoma ignitum Gorham, 1880, Trans. Ent. Soc. London, p. 83; 1881, 'Biol. Cent. Amer.,' (Coleoptera) III, part 2, p. 55.
Aspidosoma polyzonum Gorham, 1880, Trans. Ent. Soc. London, p. 83.
Aspisoma ignitum E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 21.

Pronotum brownish yellow, with four black stripes on disk (of which the two inner are the longer) separated by spots of rosy yellow. Scutellum brown. Elytra brown, with a narrow rectangular yellow spot on the margin, extending one-fourth

from base, and with three yellow lines on the disk. In the male the last ventral abdominal segment is short and emarginate; in the female it is triangular and rounded at the apex. Length, 11–14 mm.

This widely distributed species is very variable; the prothoracic stripes may be sharply defined or obscured by the paler color; the yellow spot at margins of elytra also varies in extent, and the yellow lines on disk of elytra may be lacking. The most strongly marked form, in which the three discal lines are very well marked for almost the entire length of the elytra, and even a fourth, starting from the humerus, coalescing with the marginal spot and continuing beyond it, can be distinguished, has been called variety *polyzonum* by Chevrolat, 1834, 'Col. Mex. Cent.,' I, fasc. 3, No. 51, and recognized by E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 22. Most of the Antillean specimens we have seen belong to this variety.

The following data will give some idea of the distribution of this species.

Recorded from Cayenne, South America, by Motschulsky; Central America to Yucatan by Gorham; St. Pierre and Fort de France, Martinique, and Ste. Anne, Guadeloupe, by Fleutiaux. Specimens in the U. S. National Museum collection from the island of Trinidad. We have seen specimens from the following localities in the West Indian Islands. Coll. U. S. Nat. Mus.: Dominica, June and July, (H. W. Foote); Dominica, (A. H. Verrill). Coll. British Mus.: St. Kitts, (J. J. Quelch). Coll. Amer. Mus. Nat. Hist.: Mt. Pelée, Martinique, April, (P. B. Whelpley); Roseau, Dominica, July, (F. E. Lutz). Coll. H. F. Wickham: Dominica, November, (A. F. Porter).

The specimens from Trinidad and Dominica in the National Museum collection were determined by E. Olivier as this species.

PYRACTOMENA LeConte

1850, 'Agassiz, Lake Superior,' IV, p. 228

This genus comprises about nine species which occur in the United States, Mexico, and Central America, as far south as Panama; also three species, including a new species described in this paper, from the more northern islands of the West Indies.

The species are apparently separated from *Photinus* by the angulated form of the pronotum. We do not agree with E. Olivier in substituting the name *Lecontea* for *Pyractomena* on account of the similarity in spelling to *Pyractonema* Solier.

Pyractomena galeata E. Olivier

Pyractomena galeata E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 91.
Lecontea galeata E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 23.

Pronotum yellow, with a large triangular black spot extending almost to apex. Scutellum yellow. Elytra black, bordered with yellow. Male with fifth and sixth ventral abdominal segments long, waxy white; the last segment truncate or slightly emarginate; female with all the segments brilliant, the last segment triangular, incised. Length, 10–11 mm.

Recorded from Porto Rico and St. Thomas by E. Olivier. We have seen specimens from the following localities in Porto Rico. Coll. U. S. Nat. Mus.: Fajardo and Arroyo, February, and Aguadilla, January, (Aug. Busck). Coll. Amer. Mus. Nat. Hist.: Manati, Aibonito and Arecibo, June, (Lutz and Mutchler); Santa Rita, October, (E. G. Smyth). We have also seen one specimen from Vieques Island, February, (Aug. Busck), Coll. U. S. Nat. Mus.

The National Museum specimens were determined by E. Olivier.

Pyractomena watsoni,[1] new species

Figure 28

Elongate, brown. Pronotum yellow with an elongate, somewhat triangular, brown spot on the disk which does not quite extend to the apical or basal margins; there is also a brown spot on each side margin about midway between the apex and base, which does not extend to the very edge of the side but leaves the margin very narrowly yellow. Scutellum brown. Elytra margined with yellow, except at base. Underside of body brown.

Fig. 28. *Pyractomena watsoni*, new species.

Male.—Antennæ brown; basal joint slightly paler; second and third joints slightly paler at their base. Pronotum (in specimen at hand) with the dark marginal spots coalescing with the middle spots at the basal part. First three ventral abdominal segments narrowly yellow at the middle; fourth and fifth segments yellowish white with an indentation on each side slightly nearer the base than apex and about midway between the median line and side margins. These segments margined at the sides with brown, the brown color not quite reaching the apex of the fourth and to about the apical two-thirds of the fifth segment; sixth segment brown. Last dorsal segment broadly crescently truncate. Legs brown, basal two-thirds of femur and tibiæ yellow. Length, 8.25 mm.

Female.—Underside brown; sides of abdominal segments bordered with yellow and central portion of all but the last two more or less yellow, last two segments yellow at apex; apical segment with a small /\-shaped incision at the apex. Last dorsal segment as in the male. Length, 10 mm.

Hispaniola: Dominican Republic.

Holotype male, No. 24540, and allotype female, No. 24541, San Lorenzo, June 29, 1915, (F. E. Watson), Coll. Amer. Mus. Nat. Hist.

[1]Dedicated to Frank E. Watson, in recognition of his success in collecting Lampyridæ on his several Antillean expeditions.

This species is very close to *vitticollis* Motschulsky and may be a variety of that species, but differs in having one elongate spot ("band") on the disk of the pronotum and the spots on the sides are brown instead of red or orange. The scutellum is concolorous and not margined with flavous as in *vitticollis*. It also approaches *angulata* Say in color and in the markings on the pronotum and elytra.

Pyractomena gamma (Jacquelin Duval)

Photinus gamma Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 85. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 251.

Lecontea gamma E. Olivier, 1910, 'Coleop. Catalog.,' part 9, p. 25; 1912, Rev. sci. du Bourbonnais, XXV, p. 23.

Pronotum yellow, with four brown vittæ, the two internal ones prolonged to the apex. Elytra brown, with the suture, external margin, and a longitudinal discal line yellow. Length, 8.7 mm.

Recorded from Cuba, Collection Guérin-Méneville, by Duval, and throughout the island by Gundlach. We have seen specimens from the following localities. Coll. U. S. Nat. Museum: Cayamas, Cuba, May, (E. A. Schwarz); Havana, Cuba, (C. F. Baker). Coll. Acad. Nat. Sci. Philadelphia: Cuba, (Poey Coll.). Coll. Carnegie Mus.: Los Indos, Isle of Pines, October, (G. Link). Coll. Amer. Mus. Nat. Hist.: Guane, Cuba, September, (F. E. Lutz); Montego Bay, Jamaica, March, (J. A. Grossbeck).

Pyractomena vitticollis Motschulsky

Pyractomena vitticollis Motschulsky, 1853, 'Etudes Entom.,' I, p. 38; idem, II, 1854, p. 38. Gorham, 1880, Trans. Ent. Soc. London, p. 33.

Lecontea vitticollis E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 23.

Pronotum testaceous with two very approximate brown vittæ, each having at base an orange spot which reaches the margin in some examples. Elytra black, bordered with testaceous. Scutellum black, bordered with yellow. Length, 8.6 mm.

Recorded from St. Domingo by Motschulsky, Gorham and E. Olivier. We have not seen any specimens which agree with the descriptions.

Photinus Castelnau

1833, Ann. Soc. Ent. France, II, p. 141.

This genus, to which the abundant insects known as "fireflies" belong, as defined by Castelnau, would include several other genera, but a later résumé by Lacordaire, 1857, 'Hist. Nat. Insect. (Coléoptères),' IV, pp. 321–325, was in great part followed by Gorham, 1880, Trans.

Ent. Soc. London, p 22. The genus as defined by the latter author includes the West Indian species which were separated from *Photinus* and placed by E. Olivier in the genus *Pygolampis* Motschulsky. We see no good reasons for this change but, even if there were reasons, the name *Pygolampis* Motschulsky, 1853, 'Etudes Entom.,' I, p. 48, could not be used, as it was used by Germar, 1824, 'Fauna Europ.,' VIII, p. 22, for a genus in the Heteroptera.

Photinus as here defined (see p. 449) is found in all the West Indian islands and is represented by numerous species. Usually a single species is confined to one island.

A great many species, from their superficial resemblance, are difficult to separate in a key. Sexual differences are found in the ventral segments, which, however, are difficult to observe in dried, and therefore possibly distorted, specimens; there are also sexual differences in the form of the head, usually more deeply excavated between the eyes in the males than in the females. In at least two species the elytra are abbreviated in the females. The differences in the color of the upper surface supply the most convenient characters for separation. We have, therefore, divided the species of this genus into six groups, based on type of color markings, but, as these markings sometimes vary within a species, an explanation of some of these variations seems desirable before presenting a key to the groups.

In the first (*glaucus*) group we have species which are a dirty white and superficially resemble each other. *P. glaucus* and *dominicensis* from Hispaniola and *ceratus* from Jamaica have the pronotum pale, without rosy tint. *P. dubiosus* from Porto Rico shows a rosy tint on the disk of the pronotum. All of the species, especially *ceratus* and *pallens*, may have the disk of the pronotum slightly darker than the margins.

The species in the next (*xanthophotis*) group also have the elytra without markings, some of them being very similar to those in the first group. *P. ebriosus:* the dark spot on the disk of the pronotum in one of our specimens has nearly disappeared, leaving only two small lines on each side of the disk to indicate the spot, but the elytra is enough darker than the thorax to consider the species as belonging in this group. *P. triangularis* is another pale-colored species, but it can be separated from all of the others by the pronotum being triangularly produced at the apex. The spot on the pronotum of this species is large and seems to be constant. The other species in this group, excepting in the extreme cases, have the elytra much darker than the margins of the pronotum.

Pantoni group.—In this and the following groups, the elytra are more or less bicolored. They have paler margins or other markings.

Those in the *pantoni* group are simply narrowly margined with paler color. The species *pantoni* has the lateral pale margins broader than the sutural. *P. suavis* is a pale-colored, not very well-marked species, but in fully mature specimens the pale margins are similar to, but not as well marked as in, *pantoni*. The rest of the species in this group have the margins very markedly pale.

Nefarius group.—The species in this group are so complex that we think it better to refer the reader to the discussion under the group heading, where we have given our opinions as to synonymy, etc., of some of the species.

Vittiger group.—The species in this group are marked with longitudinal vittæ on the disk of the elytra. *P. vittiger* is dark brown and plainly shows the vitta on the disk of each elytron, but in the varieties *infernus* and *littoralis* this vitta is nearly or quite obsolete. In *limbipennis* the discal vitta is not very pronounced. *P. singularis* has several more or less broken vittæ on each elytron. *P. vittatus* may superficially be considered as belonging in the *pantoni* group, but on examination it will be found that the vittæ at the sutural part of each elytron do not run along the margins but are subsutural, more markedly so basally.

Albicollis group.—The three species in this group have the elytra black, with more or less median, transverse, white markings which separate them from all the foregoing species.

We hope the following key may assist the student in separating his species into groups, but in doubtful cases it may be well to take in consideration the locality of the species, as in our study of the family we have not found any one species distributed over widely separated islands, and to remember, also, that immature specimens do not show fully developed markings.

KEY TO THE GROUPS OF *Photinus*

1. Pronotum and elytra pale (white or dirty white) in color; disk of pronotum sometimes rosy or with small darker spots; elytra unicolorous, sometimes slightly darker than the pronotum; antennal joints sometimes appearing annulate; species 8–12 mm. in length (see also *xanthophotis* group containing more or less pale-colored species) ..... *Claucus* Group.

   Pronotoum at least in part usually paler than the general color of the elytra; pronotal disk often with a central dark spot which is sometimes longitudinally divided at the middle; elytra either unicolorous, margined with paler or with paler cross-bars or spots ..... 2.

2. Elytra unicolorous (aborted elytra of female *cubanus* margined with yellow); pronotum usually paler than the elytra, disk of pronotum usually with a dark spot (sometimes absent within the species), leaving margins paler than the elytra; pronotum triangularly produced in one species. *Xanthophotis* Group.

   Elytra with paler colored markings ..... 3.

3. Margins of the elytra usually narrowly (not sinuately) pale, without submarginal or discal markings, species 3–10 mm. in length (see also *vittiger* group which contains varieties with the discal markings nearly or quite obsolete). *Pantoni* Group.

   Margins of the elytra usually not narrowly pale, if so then combined with submarginal or discal vitta or other markings ..... 4.

4. Elytra more or less sinuately margined with pale brown, the pale color sometimes reaching the suture and dividing the dark color into apical and basal spots or merely apical or basal spots, or leaving merely a discal dark line which is sometimes prolonged inwardly, about the center and again near the apex, forming a more or less elongate basal and subapical spot along the suture. *Nefarius* Group.

   Elytra with subsutural or discal vitta or with broad, white transverse discal stripes or spots ..... 5.

5. Elytra with longitudinal subsutural or discal vitta (sometimes nearly or quite obsolete var. *infernus* and var. *littoralis*) ..... *Vittiger* Group.

   Elytra with white transverse markings sometimes appearing as broad spots on the lateral margins ..... *Albicollis* Group.

Glaucus Group

Key to Species

1. Antennal joints paler at their points of contact making them appear annulate at this point. Length, usually about 15 mm ..... *pallens.*

   Antennæ not noticeably paler at their points of contact ..... 2.

2. Antennæ (reaching approximately to base of pronotum) and palpi short, compact; ventral segments all pale, distinctly punctulate ..... *heterodoxus.*

   Antennæ and palpi longer ..... 3.

3. Ventral segments unicolorous, white or very pale brown ..... *ceratus.*

   Ventral segments not unicolorous, closely punctate ..... 4.

4. Head in male triangularly excavated, ventral segments, except penultimate, dark; head in female nearly flat, ventral segments, except the sixth, pale. *glaucus.*

   Head longitudinally excavated, more deeply in male ..... 5.

5. Ventral segments, except the last two, dark ..... *lutzi.*

   Ventral segments, except the fourth, rosy, often darker in the male .. *dubiosus.*

Photinus heterodoxus, new species

Figure 29

Female.—Elongate, parallel; yellowish above and beneath, the eyes only black; the antennæ (except first joint), the palpi, tibiæ, tarsi, and dorsal segments dusky. Head (Fig. 29) concealed beneath projecting pronotum; arcuately depressed between the eyes. Palpi short, compact. Antennæ as long as pronotum, linear, hairy, reddish brown, except first joint which is yellow. Pronotum rounded in front; hind angles produced; surface uneven, closely and finely punctate. Elytra parallel, rounded at apex, closely and finely punctate, pubescent. Ventral segments all pale, very finely punctate; the last three waxy white. Length, 12 mm.

Male.—Unknown.

Porto Rico.

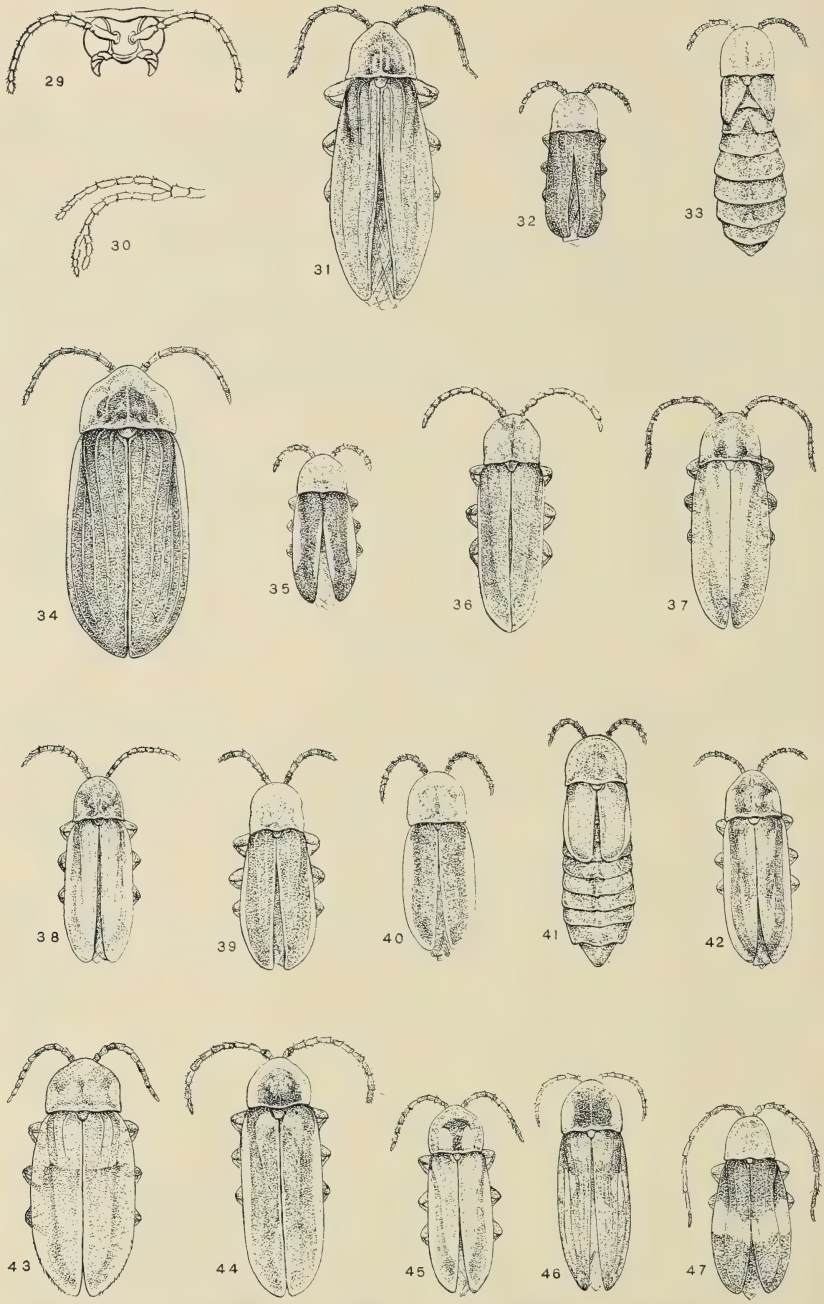


Fig. 29. *Photinus heterodoxus*, new species, front view of head.
Fig. 30. *Photinus dubiosus*, new species, deformed antennæ.
Fig. 31. *Photinus triangularis* Ernest Olivier.
Fig. 32. *Photinus nanus* (Ernest Olivier).
Fig. 33. *Photinus cubanus*, new species, female.
Fig. 34. *Photinus xanthophotis* (Gosse).
Fig. 35. *Photinus pygmæus* Ernest Olivier.
Fig. 36. *Photinus manni*, new species.
Fig. 37. *Photinus pantoni* Ernest Olivier.
Fig. 38. *Photinus suavis* Ernest Olivier.
Fig. 39. *Photinus apoplecticus* Ernest Olivier.
Fig. 40. *Photinus simplex* Ernest Olivier, male.
Fig. 41. *Photinus simplex* Ernest Olivier, female.
Fig. 42. *Photinus commissus* Ernest Olivier.
Fig. 43. *Photinus discoideus* (Sahlberg).
Fig. 44. *Photinus vittiger* (Gyllenhal).
Fig. 45. *Photinus limbipennis* Jacquelin Duval.
Fig. 46. *Photinus sanctus* Ernest Olivier.
Fig. 47. *Photinus albicollis* (Chevrolat).

Holotype, No. 24542, Adjuntas, June, 1915, (Lutz and Mutchler), Coll. Amer. Mus. Nat. Hist. Paratype, Fajardo, February, (Aug. Busck), Coll. U. S. Nat. Mus.

With a longer series, including both sexes, it might be advisable to base a new genus on this remarkable species.

Photinus pallens (Fabricius)

Pyralis.....Patrick Browne, 1756, 'Nat. Hist. Jamaica,' p. 431, Pl. xliv, figs. 9*a-b*. (Described and figured, but without name.)

Lampyris pullens Fabricius, 1798, 'Entom. Syst.,' Suppl., p. 124.

Photinus pallens Gemminger and Harold, 1869, 'Catalog. Coleop.,' VI, p. 1643 (The specific name was here emended to read *pallens*). Gorham, 1898, Proc. Zoöl. Soc. London, p. 320. E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 36, Pl. ii, fig. 11.

Photinus melanodactylus E. Olivier, 1888, Ann. Soc. Ent. France, (6) VIII, p. 56.

Pygolampis pallens E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 33.

Chalky white, with a yellowish shade. The eyes, a greater part of each antennal joint and the last two joints of the tarsi black. Disk of the pronotum often with a maroon spot. Penultimate ventral abdominal segment deeply emarginate in the male; entire in the female. Length, usually 15 mm.

This species differs from the other species of this group in its large size and parallel form. It also differs in the form of the head, which is very feebly excavated between the eyes in the male and not at all excavated in the female.

Confined to Jamaica. We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: Cinchona, Blue Mts., October, Lucca, October, McCattys' Estate, Catadupa, August, (E. J. Lund); Jamaica, (Hubbard). Coll. British Mus.: no definite locality. Coll. H. F. Wickham: Mandeville, April. Coll. Amer. Mus. Nat. Hist.: Cinchona and Catadupa, March, (J. A. Grossbeck); Montego Bay, December, Georges Valley, November; Bath, January and February, Mandeville, November, December and January, and Cumberland District, December, (F. E. Watson); no definite locality, (Wirt Robinson).

Photinus ceratus, new species

Elongate; pale brown to nearly white. Antennæ filiform, clothed with a coarse and moderately long pubescence. Pronotum rounded in front; basal angles slightly acute; apex and sides with a broad, somewhat coarsely but not closely punctate border; disk finely punctate, more or less marked with darker color; base broadly sinuate and with a row of coarse punctures on the inner margin; pubescence sparse, whitish yellow on the margins and brown on the disk. Elytra generally darker than the pronotum, but only slightly so in most of the males, granulate punctate; sparsely covered with yellowish-white pubescence. Wings dark brown. Underside waxy white, or with a slight brownish tinge, sparsely pubescent. Legs yellowish white, with three, four, or sometimes all of the tarsal joints and apex of tibiæ brown. Length, 8–10 mm.

Male.—Front of head between the eyes variable in color from dark brown to yellowish, and spotted with brown; somewhat deeply excavated in the form of a triangle, the apex of which reaches very nearly to the antennal pits. Antennæ usually with all the joints dark brown, slightly paler at the base, but in some specimens one or two of the basal joints are completely pale. Fifth and sixth ventral abdominal segments with a moderately emarginate curve at the apex; there is also an impressed spot on each side of these segments, the one on the fifth being about the middle of the side, and on the sixth above the middle, nearer the base, these impressions are nearly obliterated in one specimen.

Female.—Front of head between the eyes of the same color as in the male, but the excavation is nearly obsolete. Antennæ in all of our specimens brown with base of the joints in some specimens slightly paler. The fourth, fifth and sixth ventral abdominal segments have a curved emargination, very broad and shallow in the fourth and becoming narrower and deeper in the fifth and sixth segments.

Described from six male and nine female specimens collected in Jamaica during November and December, 1919, and January and February, 1920, by F. E. Watson, and two male specimens from the U. S. National Museum.

Holotype male, No. 24563, and allotype female, No. 24564, Cumberland District, Clarendon, December; Coll. Amer. Mus. Nat. Hist. Paratypes Nos. 24565 to 24569 inclusive; Cumberland District, December; Mandeville, November, December and January; Bath, January and February; Georges Valley, November; Coll. Amer. Mus. Nat. Hist. Two paratypes, Montego Bay and Cinchona, (E. J. Lund); Coll. U S Nat. Mus.

This species resembles *glaucus* in the general color of the upperside, but the underside has not the darker segments and is in this respect similar to *heterodoxus* but differs from that species in having antennæ and palpi similar to *glaucus*. The dorsal abdominal segments in this species are either white or nearly so, while in all the other species in the *glaucus* group the dorsal segments are dark brown. The general resemblance of this species of *glaucus* may account for the records of that species from Jamaica.

Photinus glaucus (G. A. Olivier)

Lampyris glauca G. A. Olivier, 1790, 'Entomologie,' II, No. 28, p. 13; Pl. 1, fig. 4.
Pygolampis glaucus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 30.

Oblong, greenish, becoming pale testaceous in drying. Pronotum with coarsely punctate margins; disk with a rosy blotch, channeled; disk more finely punctured than the margins. Abdomen and legs whitish. Eyes black. Antennæ and palpi dusky. The head between the eyes is nearly flat in the female; in the male it is excavated, the excavation triangular in outline. The ventral segments in the female are pale, except that the last three are more or less clouded, the sixth conspicuously dark; in the male they are darker, the anterior more or less rosy with the penultimate conspicuously waxy white, and often lying deeply in the excavation of the last segment. Length, 9–10 mm.

Type locality, St. Domingo; also recorded from Cuba (Coll. Pic.) and Jamaica by E. Olivier. We have seen specimens from the following localities in the Dominican Republic. Coll. U. S. Nat. Mus.; San

Francisco Mts., September, (Aug. Busck). Coll. Amer. Mus. Nat. Hist.: Sanchez, May and June, San Lorenzo, June, (F. E. Watson). One specimen from Cuba (Poey Coll.) in the Acad. Nat. Sci. Philadelphia.

The U. S. Nat. Mus. specimens were determined by E. Olivier.

We have numerous specimens allied to *glaucus* before us from Dominica, Porto Rico, and Cuba; the Cuban specimens, following E. Olivier, we identify as *glaucus;* the others we feel obliged to separate as distinct therefrom. We may add that such of these specimens as were in the U. S. Nat. Mus. collection were examined by E. Olivier and returned unnamed.

Photinus lutzi, new species

This species closely resembles *glaucus* but differs in the form of the head between the eyes, the excavation being broader and deeper and with the triangular incision narrowing towards apex, as well as in the color beneath. In the female, the four anterior segments are dark, the remainder pale; in the male, five anterior segments are dusky.

The species is as far as known confined to Dominica, British West Indies, the following localities being represented.

Holotype male, No. 24556; allotype female, No. 24557. Roseau, June, (F. E. Lutz); and paratypes, Nos. 24558 to 24562 inclusive, Roseau, Laudet, and Long Ditton, June, (F. E. Lutz), and Picard, June, (R. W. Miner); Coll. Amer. Mus. Nat. Hist. Paratypes in Coll. U. S. Nat. Mus.: Roseau, (A. H. Verrill); no definite locality, June and July, (H. W. Foote, Yale Exped. 1913). Paratype in Coll. H. F. Wickham: no definite locality, November, (A. F. Porter).

Photinus dubiosus, new species

This species resembles *glaucus* so closely that a statement of the differences is preferable to a detailed description. It is smaller, less elongate, much darker in color beneath. The ventral segments especially differ from these of *glaucus.* The male has six dark segments, of which the basal are slightly rosy, the others becoming darker progressively until the black sixth makes a somewhat strong contrast to the more or less waxy-white terminal segment and the very pale legs. The female, instead of being pale beneath as in glaucus, is nearly as dark as the male. Length, 8–9 mm.

Known only from Porto Rico as follows.

Holotype male, No. 24543, and allotype female, No. 24544, from Adjuntas, June; Coll. Amer. Mus. Nat. Hist. Paratypes male and female, Nos. 24545–24555 inclusive, from Adjuntas, Manati, and Arecibo, June, and Mayaguez, July, (Lutz and Mutchler); Mayaguez, January and March, (E. G. Smyth), June, (F. E. Watson); Cagues, Corozol Cave, January, (H. E. Crampton); Aibonito and Maricao, July, (H. G. Barber); Anãsco, June, (R. H. Van Zwaluwenburg); Coll. Amer. Mus. Nat. Hist. Paratypes from Arroyo, February, (Aug. Busck), and no definite locality (E. A. Wagner); Coll. U. S. Nat. Mus.

Among the numerous specimens examined, several deformities were found; one, in which the right antenna bore an eight-jointed branch on apex of second joint and a three-jointed branch on apex of eighth joint, is figured (Fig. 30).

Xanthophotis Group

Key to Species

1. Elytra only slightly darker than the pronotum; pronotum triangularly produced at the apex, disk with a central dark spot ..... *triangularis.*
   Elytra much darker than the pronotum ..... 2.
2. Species not more than 8 mm. in length ..... 3.
   Species 12 to 18 mm. in length ..... 5.
3. Length less than 3 mm.; thorax without darker markings ..... *nanus.*
   Length more than 3 mm. ..... 4.
4. Thorax and scutellum pale; female with aborted elytra ..... *cubanus.*
   Thorax with discal dark spots; scutellum concolorous with the elytra; female normal ..... *maritimus.*
5. Length 12 mm.; head deeply excavated between the eyes in the male; elytra light brown ..... *ebriosus.*
   Length 18 mm.; head not excavated between the eyes in either sex; elytra brown-black ..... *xanthophotis.*

Photinus triangularis E. Olivier

Figure 31

Photinus triangularis E. Olivier, 1912, Ann. Soc. Ent. Belgique, LVI, p. 25; Rev. sci. du Bourbonnais, XXV, p. 33.

Male.—Testaceous; body beneath except the luminous segments darker. Head excavated between the eyes. Antennæ almost entirely black. Pronotum more triangular than usual; basal angles acute; apical angles obtuse; disk darker than the margins, deeply channeled. Elytral costæ very distinct. The penultimate ventral segment of the abdomen is emarginate, though not deeply, at the apex. Length, 13 mm.

Female.—Unknown.

This species, by the form of the thorax, approaches *Pyractomena.* The excavation of the head between the eyes is not as deep as in many species of *Photinus.* The five specimens before us range from very pale whitish to yellowish brown and the disk of the pronotum is very dark in some specimens to quite pale in others, a specimen from Culebra being the darkest. The disk of the thorax and the body beneath, excepting the last two (including the eighth) abdominal segments, are very dark brown.

The type locality of this species is El Yunque, Porto Rico, We have seen five paratypes from there, also specimens from Culebra, February, (Aug. Busck); Coll. U. S. Nat. Mus.

Our figure was drawn from paratype specimens.

Photinus nanus (E. Olivier)

Figure 32

Pygolampis nanus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 29.

Pronotum reddish yellow, rugosely punctate at apex. Scutellum yellow. Elytra black with an extremely narrow sutural yellow border. Length, 2 mm.

This is the smallest species of *Photinus* in the West Indies.

Described from Cuba. We have seen three female specimens: two, Cayamas, Cuba, May 6th and 18th, (E. A. Schwarz), Coll. U. S. Nat. Mus., determined by E. Olivier; and one, Cuba, (Poey Coll. No. 1021), Coll. Acad. Nat. Sci. Philadelphia.

Photinus cubanus, new species

Figure 33

Male.—Oblong oval. Head between the eyes very deeply excavated, yellowish; eyes very large, black. Antennæ very dark brown, very moderately compressed. Pronotum yellow, rounded in front, punctate, more distinctly on the disk; disk rather feebly channeled. Scutellum yellow. Elytra brown, separately rounded at the apex, arcuate at the sides, chagrined with two or three feeble costæ. Body beneath yellow; tibiæ, tarsi and the three middle segments of the abdomen darker; penultimate segment arcuately emarginate at the apex.

Female.—(Fig. 33). Elytra, very short and dehiscent, covering only two segments of dorsum, which are modified to receive them on either side of a ∧-shaped elevation; they differ from the male elytra, also, in being margined with yellow. Head black, not excavated between the eyes; eyes small. Abdomen extending far beyond the elytra.

Length, male and female, 8 mm.

Holotype male: Cuba, from Poey Collection; Coll. Acad. Nat. Sci. Philadelphia. Allotype female: Cuba, from Poey Coll., No. 1022; Coll. Acad. Nat. Sci. Philadelphia. Paratype male; from Nueva, Gerona, Isle of Pines, July 4, 1900, (Palmer and Riley, No. 526); Coll. U. S. Nat. Mus.

The male resembles the Jamaican *P. suavis* and *P. maritimus* in form and color but differs greatly in structure. The female allotype has become somewhat distorted in drying.

The paratype specimen was borrowed from the U. S. Nat. Mus. by E. Olivier and returned by him without identification.

Photinus maritimus, E. Olivier

Photinus maritimus E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 92.
Photinus contemptus E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 34.
Pygolampis maritimus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 29.
Pygolampis contemptus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 30.

Head black, sometimes varying to light brown. Antennæ, tibiæ and tarsi, brownish. Pronotum strongly punctate, yellow, with a brown spot of variable size on the disk. Scutellum and elytra varying from pale brown to blackish brown. Apex on scutellum sometimes slightly yellow. Underside whitish yellow; first four abdominal segments often brown. Length, 7–8 mm.

Male.—With head between the eyes moderately excavated. Last ventral segment of abdomen short, emarginate at the middle.

Female.—With head between the eyes nearly flat. Last ventral segment of abdomen triangular, incised.

Described from, and we believe confined to, Jamaica. We have seen specimens from the following Jamaican localities. Coll. U. S. Nat. Mus.: Montego Bay, June, Lucca, August, Cinchona, (E. J. Lund); no definite locality, (W. Schaus and H. G. Hubbard). Coll. Acad. Nat. Sci. Philadelphia and Coll. British Mus.: no definite locality. Coll. Amer. Mus. Nat. Hist.: Mandeville, November, December and January, Bath, January; Dunrobin District, Montego Bay, Constant Spring, Kings House District, and Cumberland District, December, (F. E. Watson); Montego Bay, March and Hope Gardens, February, (J. A. Grossbeck).

We have a series of more than 150 specimens from the above localities and can see no way of separating *maritimus* from *contemptus*, there being intermediates between the lighter and darker forms which, according to the determination by E. Olivier of the specimens in the U. S. Nat. Mus. collection, is the only difference between these two species. We have, therefore, concluded to consider *contemptus* a synonym, it being merely a paler form of this species.

Photinus ebriosus E. Olivier

Photinus ebriosus E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 35.

Pygolampis ebriosus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 30.

Prothorax yellowish, with the disk largely covered by a brown spot. Elytra clear brown. Body beneath yellowish white. Length, 12 mm.

Male.—With head deeply excavated between the eyes. Last three ventral segments of the abdomen brilliant white, impressed or unipunctate on each side and emarginate at middle of the posterior margin; last segment very short.

Female.—With head very feebly excavated between the eyes and paler in color than the male. Last four ventral segments of the abdomen whitish yellow, the last segment triangular, incised.

Described from Jamaica and we believe confined to that island. We have seen specimens from Bath, January, and Mandeville, December, (F. E. Watson), also Cinchona; Coll. Amer. Mus. Nat. Hist.

Photinus xanthophotis (Gosse)

Figure 34

Pygolampis xanthophotis Gosse, 1848, Ann. Mag. Nat. Hist., (2) I, p. 268; E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 30.

Photinus opulentus E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 36.

Large, thick, trapezoidal, oblong, broad. Head in male and female very feebly impressed, ornamented with yellow spots. Prothorax yellowish brown with a darker spot on the disk. Elytra and scutellum brown-black. Abdomen of a paler color with the last three or four segments brilliant waxy white. Length, 18–20 mm.

The original description by Gosse reads as follows: "Length 9 lines [18 mm.] breadth 3¾ lines [7.5 mm.]. Elytra smoke-black; thorax drab,

the central portion dark brown; abdomen pale, the last three or four segments cream white. Specimens in British Mus."

This species was originally described from Jamaica and we believe it to be confined to that island. We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: Montego Bay, June, (E. J. Lund). Coll. Acad. Nat. Sci. Philadelphia: Bath. Coll. Amer. Mus. Nat. Hist.: "Jamaica," July, (Wirt Robinson).

Pantoni Group

Key to Species

1. Pronotum with dark spot or markings on the disk or apex . . . . . 2.
   Pronotum yellow or rosy, margins generally paler . . . . . 5.
2. Pronotum with dark spot on apical portion, length 4 mm. or less . . . . *pygmæus.*
   Length 8–10 mm . . . . . *manni.*
   Pronotum with dark spot on disk, length 6–15 mm . . . . . 3.
3. Discal dark spot on pronotum longitudinally divided in the middle, with pale line, length 7–9 mm . . . . . *pantoni.*
   Discal dark spot on pronotum not longitudinally divided . . . . . 4.
4. Discal spot on pronotum more or less elongate, margins grayish brown, basal angles slightly paler, length 6 mm . . . . . *suavis.*
   Brownish gray with margins of pronotum more or less whitish; outer margins of elytra, especially towards the apex, black; length 12 to 15 mm. (from description only) . . . . . *elongatus.*
5. Pale margins of the elytra narrow; female with normal elytra . . . . . *apoplecticus.*
   Lateral pale margins of the elytra broader than the sutural; female with aborted elytra . . . . . *simplex.*

Photinus pygmæus E. Olivier

Figure 35

Photinus pygmæus E. Olivier, 1899, Bull. Soc. Zoöl. France, p. 92.
Pygolampis pygmæus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 29.

Antennæ long, thick. Prothorax narrowed in front and feebly angulate at apex, yellow, or rosy bordered with yellow, with a small black spot reaching the apex. Scutellum black. Elytra black, rugose, finely margined with yellow; the apical angle entirely black. Body beneath, leathery brown; the last two ventral segments brilliant white. The excavation of head between the eyes cannot be satisfactorily observed in the few specimens before us, but it is apparently not as pronounced as usual in the male. Length, 3–3.5 mm.

The name used in the original description of this species was spelled *pygmæus* but in the list of 'Espèces et genres Nouveaux,' 1899, Bull. Soc. Zoöl. France, XXV, p. 244, Olivier emended it to read *pygmæus.* This emendation was also used by him in 1912.

Described from Cuba. We have seen specimens from Cayamas, Cuba, May and June, (E. A. Schwarz); Coll. U. S. Nat. Mus., and Soledad, Cuba, June, (Barnum Brown); Coll. Amer. Mus. Nat. Hist.

Photinus manni, new species

Figure 36

Male.—Elongate, parallel. Eyes large. Head black, moderately excavated between the eyes. Antennæ black, compressed. Pronotum rounded in front, concealing the head; explanate margins punctate; disk impunctate, finely channeled, rosy-testaceous with a dark transverse subapical spot. Elytra separately rounded at the apex, chagrined with one or two costæ, blackish. Each elytron narrowly margined with yellow, except at base. Body beneath and legs blackish. Last three segments of abdomen luminous, irregularly impressed, feebly emarginate at the middle. Length, 8–10 mm.

Female.—Unknown.

Described from Bahamas, Mangrove Cay and Andros Island, May and June, 1917; W. M. Mann, collector.

Holotype, No. 24589, Mangrove Cay and six paratypes, No. 24590; Coll. Amer. Mus. Nat. Hist. One paratype has been deposited in the U. S. National Museum.

This species resembles *P. collustrans* LeConte, from Texas and Florida, in size and coloration but differs in the flattened antennæ.

Photinus pantoni E. Olivier

Figure 37

Photinus pantoni E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 36.

Pygolampis pantoni E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 32.

Oblong, elongate, brown. Head of the male with a much deeper excavation between the eyes than that of the female. Antennæ annulate. Pronotum yellowish; disk dark brown, the dark color generally divided by a paler, longitudinal, median line. Elytra brown, with the suture narrowly and the external margin widely bordered with yellowish white. Body beneath more or less blackish, except last abdominal segment whitish. Length, 7–9 mm.

The description given by E. Olivier refers to mature specimens; many of ours are immature and, in such, the feeble development of the brown color is hard to see.

It is interesting to note that in the specimens examined by us the ventral abdominal segment preceding the last, or palest segment, is often the darkest of all.

Described from and, as far as known, confined to Jamaica. We have seen specimens from the following locations. Coll. U. S. Nat. Mus.: Cinchona, Blue Mts., June and October; Catadupa, McCatty's Estate, August, (E. J. Lund). Coll. Acad. Nat. Sci. Philadelphia: Jamaica. Coll. Amer. Mus. Nat. Hist.: Cinchona, February, (J. A. Grossbeck); Cumberland District, December, and Bath, January, (F. E. Watson).

Photinus sauvis E. Olivier

Figure 38

Photinus suavis, E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 38.
Pygolampis suavis E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 28.

Opaque black. Pronotum and elytra margined with yellowish white. Scutellum, legs, and abdomen whitish. Male with very deep excavation between the eyes. Length, 6 mm.

In this species especially, the variation in color due to immaturity or lack of pigment is liable to be puzzling, for in the many specimens collected by Mr. Watson, while the majority might be described as "opaque black," there are a number that are much paler in color and a few that are distinctly pale brown. The species has, however, a short, ovate form that is unmistakable.

Described from and, as far as known, confined to Jamaica. We have seen specimens from the following localities. Mandeville, November, December, and January, Dunrobin District, December, Montego Bay, December, and Bath, January, (F. E. Watson); Coll. Amer. Mus. Nat. Hist.

Photinus elongatus (Motschulsky)

Ellipolampis elongatus Motschulsky, 1854, 'Etudes Entom.,' II, p. 35 [1853, idem, I, p. 36, no description].
Photinus elongatus Gorham, 1896, Proc. Zoöl. Soc. London, p. 320.
Ellipolampis elongatus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 34.

We have not seen any specimens which agree with Motschulsky's description of this species and have, therefore, followed earlier authors and placed the species in the genus *Photinus*. The following translation of the descriptions of Motschulsky's genus *Ellipolampis* and species *elongatus* (this being his type of the genus) may be useful in identification.

Ellipolampis M., n. g.—Shape elongate-ovate, a little narowed behind, rather convex. Pronotum halfmoon-shaped, raised in the middle; margined and often marked with two translucent spots as in the *Lychnuris*. Antennæ not longer than half the body, filiform; first joint as long as the third or a little longer; the fourth and following joints of equal length, a little compressed. Scutellum broadly, arcuately truncate. Elytra with the veins more or less visible. First joint of the hind tarsi not longer than the two following together, the fourth shorter and bilobate. Last dorsal segment of the abdomen rounded; the last ventral segment broadly emarginate; the penultimate sinuate in the middle. Lobes not visible. Type: *Ellipolampis elongata* Mannerheim, from the Island of St. Thomas in the Antilles. *Ellipolampis elongata* Mannh.; rather regularly ovate and distinctly impressed along each lateral margin. Brownish gray with the margins of the pronotum and of the elytra[1]

[1]The margins of the elytra here referred to must mean the sutures, as in the following part of this sentence the outer margins of the elytra are described as blackish.

more or less whitish; the outer margins of the elytra, especially toward the apex, the wings, the legs, the antennæ and the underside of the body, blackish. Eyes black. The entire insect pubescent above. Length, 6–7½ lines; width, 2⅓–3⅓ lines. Antilles.

Photinus apoplecticus E. Olivier

Figure 39

Photinus apoplecticus E. Olivier, 1899, Bull. Soc. Zoöl. France, XXIV, p. 92.
Pygolampis apoplecticus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 28.

Male.—Head black; excavation between the eyes deep. The eyes are very large, spherical objects, that seem to compose nearly the entire head. Pronotum testaceous, elongate, wide, with the sides parallel at base, slightly wider in front of the base, and suddenly rounding at the apex. Elytra brown, finely bordered with whitish yellow. Underside of body black; abdominal segments brownish, bordered with testaceous; last segment yellow. The female is unknown to us. Length, 5–6 mm.

We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: three specimens, Cayamas, Cuba, March, May and June, (E. A. Schwarz). Coll. Acad. Nat. Sci. Philadelphia: one specimen, Cuba, (Poey Coll. 1631). Coll. Carnegie Mus.: one specimen, Nueva Gerona, Isle of Pines, June.

The National Museum specimens were determined by E. Olivier.

Photinus simplex (E. Olivier)

Figures 40 and 41

Pygolampis vitiosus var. *simplex* E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 28.

Male.—(Fig. 40). Oblong, parallel, testaceous. Antennæ brown, basal joint testaceous. Head moderately excavated between the eyes, the excavation granulate. Pronotum rounded in front, coarsely punctate at apex and sides, more finely on the disk; disk channeled, rosy. Elytra covering the abdomen, black; margins, excepting the base, bordered with testaceous. Body beneath and legs testaceous; abdomen pale brown, last three segments white. Length, 5–6 mm.

Female.—(Fig. 41). Slightly paler in color than the male. Head feebly excavated between the eyes. Elytra less than one-half as long as the abdomen. Otherwise as in the male. Length, 5 mm.

Allotype female, No. 25077, Coll. Amer. Mus. Nat. Hist.: Laudet, Dominica, June 12, 1911, collected by F. E. Lutz.

The male of this species was described as from San Domingo, perhaps erroneously, by E. Olivier. We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: Dominica, March, (H. G. Hubbard); June and July, (H. W. Foote, Yale Exp., 1913). Coll. Amer. Mus. Nat. Hist.: Laudet, Roseau and Long Ditton, Dominica, June, (F. E. Lutz); South End of St. Croix, (R. W. Miner).

The specimens in the U. S. National Museum were determined by E. Olivier as *vitiosus* var. *simplex* in 1911, which was prior to his descrip-

tion of the variety. We believe these specimens, which were all males, were all or part of the material on which he based his reasons for making this new variety and the locality San Domingo was an error in copying the locality record. The female in the American Museum collection is doubtless conspecific. It has aborted elytra and, as this character apparently does not occur in the species *vitiosus*, we have raised the variety to specific rank. The species bears a closer resemblance to *apoplecticus* from Cuba than to *vitiosus*.

Nefarius Group

There are five species listed by Ernest Olivier, 1912, Rev. sci. du Bourbonnais, XXV, pp. 25–27, which would come in this group, but we have concluded that only three of these are really species, the others being merely extremes in size or due to coalescence of basal and apical elytral spots, or the breaking up of the elytral bands into basal and apical spots, in markings. There has also been considerable difference of opinions in the citations of a species described under the name *blandus* by Motschulsky and one described from Cuba by Jacquelin Duval under the same name. We believe that the species described by these two authors are entirely different. The following list of somewhat complicated citations will show where the Duval species has been considered a synonym of the Motschulsky species and where E. Olivier, possibly through neglect or for convenience, has entirely ignored the Duval species in two of his citations and the Motschulsky species in a later paper on the West Indian Lampyridæ.

Pygolampis blandus Dejean, 1837, 'Catalog. Coleop.,' III, p. 115 (without description); locality, Cuba.

Pygolampis blanda Dejean. Motschulsky, 1854, 'Etudes Entom.,' p. 25; locality, St. Domingo. Size "Long, 2¾ lines, large, 1¼ lines."

Photinus Lacordaire, 1857, 'Hist. Nat. Insect. (Coléoptères),' IV, p. 323. With the following note referring to the Motschulsky species: "Le *Pyg. blanda* de Dejean, petite espéce du Bresil que M. de M. place dans ce groupe. A les deux derniers segments abdomineux et le facies d'une *Ellipolampis*." This author apparently believed the type locality of the species to be San Domingo, Brazil.

Photinus blandus Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 87. Locality Cuba, Coll. Guérin-Méneville. Size "Long, 6⅔–11 millim."

Photinus blandus Motschulsky. Gemminger and Harold, 1869, 'Catalog. Coleop.,' VI, p. 1641; locality, Cuba. These authors cite Duval's species as a synonym and also refer to Dejean's and Lacordaire's citations.

Photinus blandus Jacquelin Duval. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 252. Cuba, with note by Gundlach "Se encuentre en toda la isla."

Photinus blandus Motschulsky. Gorham, 1880, Trans. Ent. Soc. London, p. 25. "Cuba: Mus. Brus. [Guérin-Mén.]; Coll. Chev." This citation probably refers to the Duval species, it being from Guérin-Méneville.

Photinus blandus Motschulsky. E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 34 (sp. 19). Locality St. Domingo. No reference is made to the Duval species in synonymy or otherwise.

Photinus blandus Motschulsky. E. Olivier, 1910, 'Coleop. Catalog.,' part 9, p. 27. Locality St. Domingo. This catalogue, supposedly containing a complete bibliography, does not mention the Duval species.

Pygolampis blandus Jacquelin Duval. E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 27. Locality Cuba. This paper, which is a review of the West Indian Lampyridæ, does not mention the Motschulsky species in synonymy or otherwise.

We have not seen any specimens which agree with Motschulsky's description of *blandus*, which, according to Lacordaire, is a Brazilian insect, and we are inclined to accept it as such, there being no authentic records of it having been found in Santo Domingo (Hispaniola).

Motschulsky's species is generally smaller and the elytral markings differ from the Duval species; for this reason and the fact that they were described from different places, we believe they are not synonymous. The name being used by Motschulsky prior to Duval would naturally cause *blandus* Duval to be a homonym and another name must be used for the Cuban species. The name which should be used, according to our identification of the species, in *nefarius* E. Olivier, as in our study of the Cuban specimens which belong in this group we have found intermediates between the smaller specimens which were determined as *blandus* Jacquelin Duval and the larger ones (all of which are females), determined as *nefarius* E. Olivier. These determinations were made by the author of the latter species. We also consider that the specimens in the U. S. National Museum collection which were determined by E. Olivier as "*4-notatus* Motschulsky" are extremes in markings (with the sinuate elytral line broken into apical and basal spots) and should be placed under *nefarius*.

In our studies of this group we have seen many convincing proofs of the tendency of the elytral bands to break up into more or less elongate basal and apical spots, or, if one looks at it the other way, of the spots coalescing and forming a more or less continuous band. With this tendency in mind we have carefully read over the Castelnau description of *quadrimaculatus* and the Motschulsky descriptions of *interrupta* and have concluded that they are synonymous. Taking *quadrimaculatus* Castelnau as the type, which shows (according to description) the bands broken up into spots, we have *interrupta* Motschulsky with the spots forming more or less continuous bands.

We have not seen any specimens which agree with the description of *quadrinotata* Motschulsky but we believe this to be a distinct species more closely related to *nefarius* than to *quadrimaculatus*.

We will not attempt to form a key to the above species but merely note that in *quadrimaculatus* the spots or bands do not reach the margins of the elytra, but in *nefarius* and *quadrinotata* they extend to the apical margins. We have also included two other species in this group, namely *commissus* and *discoideus*, which may be readily separated from the others as follows:

P. commissus.—Elytra with outer pale margin, at most, narrowly sinuate at middle, sutural pale margin broad and divided at the middle and subapical part into a more or less irregular sub-basal and subapical spot by an inward prolongation of the dark discal stripe. Thorax with a dark discal spot, sometimes longitudinally divided at the middle by a paler color.

P. discoideus.—Elytra margined with yellow and with the pale yellow color extending over, approximately, the basal third. Thorax pale yellow.

Photinus nefarius (E. Olivier)

Photinus blandus [preoccupied] Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 87. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 252.

Pygolampis nefarius E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 26.

Pygolampis blandus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 27.

The following is a translation of Duval's original description and discussion of *blandus*.

Flavo-testaceous. Head brown. Antennæ brown, base paler or testaceous. Thorax nearly semicircular; behind the middle rosy, slightly variegated. Elytra closely punctate; brown with a broad flavo-testaceous sutural and lateral line, often slightly dilated behind the middle which is abbreviated or occasionally more or less broadly joined. Penultimate abdominal segment brown; ultimate pale whitish. Femora flavo-testaceous; tibiæ and tarsi brown. Length, 6.66–11 mm.

Body elongate-oblong, dull, clad with a very fine and very short pubescence of a yellowish gray. Head brown, sometimes testaceous and brown in the center only; eyes black. Antennæ brown; testaceous or of a lighter brown at the base. Prothorax of a flavous testaceous, sometimes uniform and sometimes varied with rosy behind; almost semicircular; sides and anterior margin continuously rounded; posterior angles right; above densely punctured; punctures finer toward the middle of the disk posteriorly. Scutellum of a flavous testaceous. Elytra brown; showing on their suture a vitta shortened posteriorly and in the majority of cases a little dilated behind, and quite a wide lateral border starting from the base, widening slightly behind and ending at the posterior two-thirds or three-quarters, of a flavous testaceous, these

two longitudinal bands sometimes reunited, toward their posterior part, by the interruption more or less wide of the brown part at the middle; about of the width of the prothorax at their base; widening slightly behind, showing their greatest width toward the posterior two-thirds, contracted thereafter gradually toward the extremity, where they are each rounded; above very densely punctured; slightly chagrined, showing two longitudinal lines that are slightly raised, very slightly marked, arranged altogether like the two yellow longitudinal lines of *Ph. gamma*. The body beneath flavous testaceous; penultimate, or the two segments before the last abdominal segment brown; the last segment a pale white. Femora flavous testaceous; tibiæ and tarsi brown. Collection of M. Guérin-Méneville.

We have also made the following translation of E. Olivier's description and discussion of *nefarius*, which in our opinion agrees with Duval's description in all of the essential points.

Elongate rufous. Antennæ black; the first two joints rufous. Prothorax in front attenuate and angulate with margin rugoso-punctate; red; disk rosy; sulcate. Scutellum testaceous; apex truncate. Elytra not broader than prothorax; oblong-elongate, punctate, costate, rufo-testaceous, with two black maculations on each, one basal triangular prolonged to beyond the middle, covering the suture but not the margin, the other ones smaller, these two maculations sometimes joined. The two penultimate ventral segments black; ultimate and pygidium waxy. Tibiæ and tarsi black. Length, 12 mm.

Elytra oblong, elongate, reddish testaceous; each showing two black spots, one triangular starting from the base and prolonged to about the middle of the elytral length always leaving the suture narrowly and the margin more widely bordered with testaceous. The other spot covers the apical angle of which it colors the suture and the marginal side but not reaching past one-third the length of the elytra.

In some specimens the two spots are united by a narrow stripe which gives them a resemblance to *P. divisus* Gemm. but they can always be distinguished by the apical spot entirely covering the angle including the margin and suture; by the prothorax being much more elongate and angulate in front; by the fifth and sixth segments of the abdomen being black; by the darker color of the tibiæ and tarsi; etc., etc.

Recorded from Cuba. We have seen specimens as follows. Coll. U. S. Nat. Mus.: Cayamas, May, (E. A. Schwarz); El Guama, March, (Palmer and Riley); Havana, (Roig). Coll. Acad. Nat. Sci. Philadelphia: "Cuba," (Poey Coll.), Coll. Amer. Mus. Nat. Hist.: Baños de Ciego, Montero, (Barnum Brown); Santiago de Cuba.

Photinus quadrimaculatus (Castelnau)

Photinus quadrimaculatus Castelnau, 1840, 'Hist. nat. et icon. Coléop.,' I, p. 269.
Pygolampis quadrimaculata Motschulsky, 1854, 'Etudes Entom.,' III, p. 24. E Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 25.
Pygolampis interrupta Motschulsky, 1854, 'Etudes Entom.,' III, p. 24.
Photinus divisus Gemminger, 1870, 'Coleop. Hefte,' VI, p. 119. E. Olivier, 1910, 'Coleop. Catalog.,' part 9, p. 28.
Pygolampis divisus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 25.

The translation of Castelnau's description of this species is as follows:

Length 4½ lines, width 1¼ lines. Yellow, with a rounded blackish spot on the humeral angle, and another much larger and oval near the extremity of each elytron. Extremity of legs and antennæ black, the latter with the first joint yellow; the two last abdominal segments phosphorescent. Santo Domingo.

We have seen specimens from the following localities: Port au Prince, Haiti, (R. J. Crew), Coll. H. F. Wickham; and San Domingo City, Dominican Republic, December or January, Coll. Amer. Mus. Nat. Hist.

In one specimen from Port au Prince the apical elytral spots extend to the apical margin.

Photinus quadrinotatus (Motschulsky)

Pygolampis quadrinotata Motschulsky, 1854, 'Etudes Entom.,' III, p. 24. E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 25.

The following is a translation of Motschulsky's original description of this species:

Size and form of *L. splendidula*, but a little more oval and the thorax more elongate. The color testaceous; eyes, ten last joints of antennæ, femur, tarsi, and four spots placed in the form of a cross on the elytra brownish black, a well-defined line separates the two large spots which occupy the base also the two small ones which reach the extremity of the elytra. Length, 3½ lines, width 1½ lines. Antilles (St. Domingo).

As said before, we have seen no specimens which agree with this description.

Photinus commissus E. Olivier

Figure 42

Photinus commissus E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 34.
Pygolampis commissus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 28.

Elongate, subparallel. Antennæ and mandibles flavous. Prothorax round in front; closely punctate; disk marked with a quadrate dark spot. Scutellum piceous. Elytra scarcely wider than the thorax. External margin flavous; suture broadly flavous, divided about the central part by a somewhat irregular dark line. The body beneath and legs flavous. Length, 5–7 mm.

A pretty little species, distinct by the pattern of the elytra and pale color of parts beneath. The brown spot of prothorax is sometimes divided by a narrow yellow line. The discal dark part of the elytra in some specimens is reduced to a narrow line, which is dilated at middle and has a transverse oblique branch reaching the suture; in some specimens it is interrupted beyond the branch.

Described from Jamaica and, we believe, confined thereto. We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: Salt Pond, Montego Bay, June, (E. J. Lund). Coll. British Mus.:

"Jamaica." Coll. H. F. Wickham; Mandeville, April, (Van Duzee). Coll. Amer. Mus. Nat. Hist.: Mandeville, November, December and January, and Montego Bay, December and January, (F. E. Watson); Montego Bay, March, (J. A. Grossbeck).

The U. S. National Museum specimens were determined by E. Olivier.

Photinus discoideus (Sahlberg)

Figure 43

Lampyris discoideus Sahlberg, 1823, 'Peric. Entom.,' p. 3, Pl. I, fig. 1. Thon, 1829?, 'Entomol. Arch.,' II, pp. 13 and 80, Pl. II, fig. 1.

Photinus discoideus Gorham, 1880, Trans. Ent. Soc. London, p. 25. Fleutiaux and Sallé, 1889, Ann. Soc. Ent. France, (6) IX, p. 416.

Pygolampis discoideus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 27.

Yellow. Elytra, each with an elongate, apical brown spot on the disk, which extends to the basal third, but not reaching either the suture or external margin. Length, 10 mm.

Fleutiaux and Sallé (1889) record this species from Camp Jacob, Guadeloupe, January and March, on flowers and leaves; Gourbeyre, February; Gommiex, April, (Delauney); very common everywhere, (Vitrac); Common name, "Mouche à feu." We have seen specimens from Guadeloupe in the Coll. U. S. Nat. Mus., 4000 ft. elev., July 30, (Aug. Busck), and in the Coll. Fleutiaux.

The specimens in both of the above collections were determined by E. Olivier.

Vittiger Group

Key to the Species

1. Pronotum with a darker discal spot ..... 2.
   Pronotum without a dark discal spot ..... 4.
2. Discal spot on pronotum more or less rounded; elytra with pale discal vitta, distant from the suture (dark specimens with the discal vitta, nearly obliterated var. *infernus*, or paler specimens in which the vitta is obsolete or barely preceptible var. *littoralis*) ..... *vittiger.*
   Discal spot on pronotum more or less elongate, or squarely outlined ..... 3.
3. Discal spot on pronotum more or less elongate, elytra margined with paler and with paler discal vitta ..... *limbipennis.*
   Discal spot on pronotum more or less squarely outlined and longitudinally divided in the middle with paler color; elytra margined with paler and with more or less incomplete paler discal vittæ ..... *singularis.*
4. Pronotum yellow; elytra brown entirely bordered with whitish yellow and with median yellow vitta, reaching neither base nor apex (from description only). *vitiosus.*
   Pronotum rosy, margined with yellow; elytra dark with paler external margins and subsutural vitta ..... *vittatus.*

Photinus vittiger (Gyllenhal)

Figure 44

Lampyris vittigera Gyllenhal, 1817, in Schönherr's 'Syn. Insect.,' I, part 3, appendix, p. 21.

Photinus vittiger Motschulsky, 1853, 'Etudes Entom.,' II, p. 41; Gorham, 1880, Trans. Ent. Soc. London, p. 25; 1898, Proc. Zoöl. Soc. London, 1898, p. 320.

Pygolampis vittiger E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 31.

Oblong, elongate. Antennæ serrate, longer than half the body. Prothorax yellow; margins strongly punctate; disk brown, channeled. Scutellum triangular, yellow. Elytra elongate, subparallel, brown, with the suture, external magrin, and a median vitta yellow; the vitta starts at the callus, varies in length, but rarely reaches the apical angle. Body beneath and legs pale testaceous, sometimes brownish; ventral abdominal segments annulate with brown.

Length, according to Motschulsky, 3½ lines, but the specimens which were loaned us for study by M. Ed. Fleutiaux measure 12 mm. in length and were determined by E. Olivier as this species.

The variations in the development of the elytral vittæ are the foundation for the varieties named below.

Rev. T. A. Marshall, 1878, Trans. Ent. Soc. London, Proc., p. xxx, says of this species: "The so-called 'vers luisant' of Martinique. Both sexes shine equally, and exhibit a beautiful effect, like falling stars, among the trees on the mountains. See Newman, Zoölogist, p. 42."

E. Olivier's record for this species is "Martinique; Fort-de-France, Saint-Pierre (coll. Fleutiaux)."

The above locality record is the same as the locality on the specimens loaned to us by M. Ed. Fleutiaux.

Photinus vittiger var. **littoralis** (Motschulsky)

Ellipolampis littoralis Motschulsky, 1853, 'Etudes Entom.,' II, p. 35.

Photinus littoralis Gorham, 1880, Trans. Ent. Soc. London, p. 25; 1898, Proc. Zoöl. Soc. London, p. 320.

Pygolampis littoralis E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 31.

Oblong, elongate. Prothorax yellow, disk darker; marginal edge more elevated than in the species. Scutellum yellow, triangular. Elytra brown, bordered with yellow, narrowly on the suture, more widely on external margin. Male mesosternum and first segments of abdomen nebulous, the last three brilliant yellowish-white; female, beneath, entirely whitish yellow. Length, 8 mm.

Through the kindness of M. Ed. Fleutiaux, we have been able to examine a specimen from Saint-Pierre, Martinique, which was determined as this variety (species) by E. Olivier. It measures 12 mm. in length and seems to be *vittiger* lacking the vitta. There are also six specimens from Trinidad in the U. S. National Museum collection which were determined by E. Olivier as *littoralis*. These specimens do not agree

with the above description, but rather seem related to *glaucus*. They are 10 mm. in length.

The locality given by Motschulsky is Martinique; and by E. Olivier, Saint-Pierre and Trinité, Martinique.

Photinus vittiger var. **infernus** (E. Olivier)

Pygolampis infernus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 31.

A translation of E. Olivier's remarks on this variety is as follows.

A fine species, remarkable for its color which is entirely black except following parts, viz.: mandibles; prothoracic border, widely at sides, narrowly along the base; extreme apex of scutellum; sutural edge and margin of elytra and a short vitta at middle; the coxæ; internal part of femora; and a narrow hind margin of ventral segments. Length, 13–14 mm. Martinique, Mt. Pelée (Coll. Fleutiaux).

Through the kindness of M. Ed. Fleutiaux, we have been able to study the specimens determined by E. Olivier. They seem to be dark forms of *vittiger*. The color above and beneath is darkest in var. *infernus* and in one of the types, loaned by M. Ed. Fleutiaux, its darkening has nearly obliterated the discal vitta of the elytra. The color, on the contrary, is lightest in var. *littoralis*, the vitta being barely perceptible. It is in this form only that the entirely white abdomen of the female is found, so that it is quite different in appearance, but we, nevertheless, believe both to be varieties of *vittiger*.

Photinus limbipennis Jacquelin Duval

Figure 45

Photinus limbipennis Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. et Nat. de L'île de Cuba,' Anim. Artic., p. 86. Gorham, 1880, Trans. Ent. Soc. London, p. 25. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 252. E. Olivier, 1894, Ann. Soc. Ent. France, LXIII, p. 24. Gorham, 1898, Proc. Zoöl. Soc. London, p. 320.

Heterophotinus limbipennis E. Olivier, 1907, 'Gen. Insect.,' fasc. 53, p. 33; 1912, Rev. sci. du Bourbonnais, XXV, p. 33.

Male.—Head with a deep excavation between the eyes. Pronotum rounded, testaceous; disk dark brown, with a small rosy patch on each side at the base. Elytra brown, slightly darker at the base; margined, except at the base, with testaceous. Length, 8–9.5 mm.

We have not seen the female of this species but E. Olivier says that the wingless female is entirely yellowish-testaceous, with the thorax rosy and a small brown spot at the base of the abbreviated elytra. The elytra are shorter than the metathorax.

The male of this species was described by Jacquelin Duval, but the female was first recognized by E. Olivier (1894).

All of the locality records merely give "Cuba," Gundlach recording it as found throughout the island. We have seen one male specimen from Cayamas, Cuba, December 30, (E. A. Schwarz), Coll. U. S. Nat. Mus. This specimen was determined by E. Olivier as this species.

Photinus singularis, new species

Female.—Elongate, brown. Head with impressions at front ending in a somewhat long pointed angle, deeper than usual in the females of this genus; front part between the eyes and central impressed portion between the antennæ and eyes blackish brown; sides of front adjacent to the eyes and above the antennal pits pale red; mouth-parts yellow; palpi with apical joint darker. Pronotum coarsely and somewhat closely punctate; margined at sides and front with yellow; disk with large somewhat rectangular dark spot divided in the middle and bordered at the sides with reddish yellow; pubescence sparse yellow, very indistinct on margins. Scutellum yellow, coarsely punctate. Elytra brown, with yellow sutural and side margins connected at the apex; disk with yellow lines, one subsutural beginning near the base and joining with the suture at about apical two-thirds, one discal beginning at base and ending at suture near the apex, one at sides beginning at humerus and joining the margin at about apical third; side margin much flattened; broadest about the middle. Underside of thorax rosy. Prosternum and abdomen brown; abdominal segments with yellowish markings on the margins; last segment waxy. Legs yellow; central portion of femur and inner part of tibiæ longitudinally darker; tarsi darker. Length, 13 mm.

Male.—Unknown.

Holotype No. 24591, Coll. Amer. Mus. Nat. Hist.

The single specimen was collected by Dr. Chas. T. Ramsden at Sta. Maria de Loreto, Oriente Province, Cuba.

Photinus vitiosus Gemminger

Lampyris vittata Fabricius, 1792, 'Entom. Syst.,' I, part 2, p. 102; 1801, 'Syst. Eleuth.,' II, p. 105. Schönherr, 1817, 'Syn. Insect.,' I, part 3, p. 65. Cited in error as *vittata* G. A. Olivier.

Photinus vitiosus Gemminger, 1870, 'Coleop. Hefte,' VI, p. 120.

Photinus vittatus Fleutiaux and Sallé, 1889, Ann. Soc. Ent. France, (6) IX, p. 416.

Photinus vittatus (Fabricius *nec* G. A. Olivier; *vitiosus* Gemminger) Gorham, 1898, Proc. Zoöl. Soc. London, p. 320.

Pygolampis vitiosus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 27.

Form similar to *vittatus*. Prothorax yellow; elytra brown, entirely bordered with whitish yellow and with a median yellow vitta reaching neither base nor apex.

This species was described from Guadeloupe by Fabricius, who supposed it to be the same as *vittatus* G. A. Olivier, but these two species were separated by Schönherr, 1817, 'Syn. Insect.,' I, part 3, p. 35, with a note, "A specie præcedenti distincta," referring to the Olivierian and Fabrician species. Fleutiaux and Sallé seem to have overlooked this citation, as they list G. A. Olivier's species, giving *suturalis* Schönherr

and *vitiosus* Gemminger as synonyms, and cite the Guadeloupe locality on the Fabrician record. Gorham cites Guadeloupe, San Domingo, and Jamaica as localities; and E. Olivier, in his revision, merely cites Cuba.

We have seen no specimens which agree with the description of this species but can hardly believe that the records from San Domingo, Jamaica, and Cuba refer to it, as the following records of this, and allied species, seem to prove it to be a Guadeloupe species.

Both *vittatus*, described by G. A. Olivier in 1790 from Haiti, and *vittiger*, described by Gyllenhal in 1817 from Martinique, have the elytra margined with pale yellow and a more or less conspicuous vitta; the vitta is, however, near the suture in *vittatus* but not in *vittiger*. In many of the other islands, pale-margined and vittate species occur, the names of which have become confused by mistakes in identifications. Fabricius, in 1792, began this confusion by applying the name *vittatus* G. A. Olivier to an insect he credited to Guadeloupe. Nothing closely resembling *vittatus* G. A. Olivier is found in Guadeloupe as far as we know; the much larger *vittiger* Gyllenhal (1817), described from Martinique, may be what Fabricius had before him. Gemminger in 1870 treated the Fabrician name *vittatus* as cited in error and substituted *vitiosus*. E. Olivier, in his works on Lampyridæ, seems to have applied the name *vitiosus* to allied forms from other islands, probably on the assumption that the Fabrician locality was wrong. This course is hardly defensible, as Fabricius says "habitat in insula Guadeloupe, Dom. de Badier," and we have found this same reference to Guadeloupe species of other families, specimens of which have later been found there. Considering the Fabrician species to be found in Guadeloupe, the application of it as a synonym of *vittiger* may prove to be more correct than the course we have adopted of retaining it as a valid species unrecognized by us; our material from Guadeloupe is, however, insufficient to justify a synonymy not established by Fleutiaux and Sallé.

Photinus vittatus (G. A. Olivier)

Lampyris vittatus G. A. Olivier, 1790, 'Entomologie,' II, No. 28, p. 23, Pl. III, fig. 20.
Lampyris suturalis Schönherr, 1817, 'Syn. Insect.,' I, part 3, p. 65.
Photinus vittatus Gorham, 1898, Proc. Zoöl. Soc. London, p. 320.
Pygolampis vittatus E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 27.

Narrow, subparallel in form. Prothorax yellow with carmine disk. Elytra brown, with a narrow slightly oblique juxtasutural pale vitta leaving the suture dark; bordered with a testaceous margin which continues around the apex and often joins the subsutural vitta. Body beneath often tinged with rosy; fifth and sixth ventral abdominal segments blackish; the seventh with two lateral white spots or entirely white, all colors and markings, vaguely defined. Length, 7 mm.

Described from St. Domingo and Porto Rico. We have seen specimens from the following localities in the Dominican Republic. Coll. U. S. Nat. Mus.: San Francisco Mts., September, (Aug. Busck). Coll. Amer. Mus. Nat. Hist.: Sanchez, May and June, and San Lorenzo, June, (F. E. Watson); Sanchez, October and November, (Fred Hagan), La Romana, January, (H. E. Crampton); Puerto Plata, March, (Norman L. Orme, Jr.). We have also seen specimens from the following localities in Porto Rico. Coll. U. S. Nat. Mus.: Arroyo, February, and Utuado, January, (Aug. Busck). Coll. Amer. Mus. Nat. Hist.: Mayaguez, November, December and January, (R. H. Van Zwaluwenburg); Santa Rita, August, (E. G. Smyth); Guayanille, July, (H. G. Barber); Coamo Springs, January, (H. E. Crampton); San Juan, February, (F. E. Lutz); Mayaguez, Manati, Ensenada and Arecibo, June, (Lutz and Mutchler).

Albicollis Group

KEY TO SPECIES

1. Pronotum with a large dark discal spot; elytra black with an ante-median broad white cross-band or spot which sometimes extends narrowly along the outer margin to the humeri ..... *sanctus.*
   Disk of pronotum pale ..... 2.
2. Elytra with a broad, median, white, cross-band which is broader than the apical or basal black portion ..... *notatus.*
   Elytra with a narrow, median, white cross-band which is narrower than the remaining apical or basal black portion ..... *albicollis.*

Photinus sanctus E. Olivier

Figure 46

Photinus sanctus E. OLIVIER, 1909, Rev. sci. du Bourbonnais, XXII, p. 123.
Pygolampis sanctus E. OLIVIER, 1912, Rev. sci. du Bourbonnais, XXV, p. 32.

Oblong. Pronotum yellowish white with a large discal black spot. Elytra black with a wide transverse yellowish-white band, this band is often interrupted by the black color and does not reach the suture. Last three ventral segments white. Length, 10–17 mm.

Described from St. Thomas. We have not seen any specimens of this species from St. Thomas, but there are two specimens in the U. S. Nat. Mus. collection from Dominica (A. H. Verrill), which were determined by E. Olivier as *sanctus*. The other specimens before us are from the following localities. Coll. U. S. Nat. Mus.: Dominica, June and July, (H. W. Foote, Yale Exped., 1913). Coll. Brit. Mus.: Dominica. Coll. Amer. Mus. Nat. Hist.: Roseau and Laudet, Dominica, June, (F. E. Lutz).

Photinus notatus Gorham

Photinus notatus GORHAM, 1898, Proc. Zoöl. Soc. London, p. 319, Pl. XXVII, fig. 3.
Pygolampis notatus E. OLIVIER, 1912, Rev. sci. du Bourbonnais, XXV, p. 25.

Antennæ rather long, entirely fuscous. Pronotum testaceous; disk rosy, very even and smooth, central channel faintly indicated. Elytra black, with a broad, transverse, median, testaceous band, covering more than one-third of the elytral length. Legs pale; the tibiæ (a little infuscate toward the apex), and tarsi fuscous. Length, given by Gorham, 8 mm.

Gorham (1898) considered this species allied to *blandus* Motschulsky. E. Olivier, 1910, 'Coleop. Catal.,' part 8, p. 30, considered *notatus* Gorham and *quadrinotatus* Motschulsky to be synonyms of *quadrimaculatus* Castelnau, but in 1912 the latter author changed his opinion and raised both *notatus* and *quadrinotatus* to specific rank.

Two specimens, one of which is labeled "cotype," were loaned to us by the British Museum. The largest of these is barely 6 mm. in length. This size agrees with the line in Proc. Zoöl. Soc. London, 1898, Pl. XXVII, fig. 3, indicating the length of the figured specimen. The yellow markings in the specimens before us are much paler than shown in the figure.

Described from St. Vincent, leeward side, (H. H. Smith). Coll. Brit. Mus.

Photinus albicollis (Chevrolat)

Figure 47

Calopteron albicolle Chevrolat, 1858, Rev. et Mag. Zoöl., (2) X, p. 256; 1870, Ann. Soc. Ent. France, (4) X, p. 77. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 256.

Pygolampis albicollis E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 32.

Oblong. Prothorax narrow, more so apically, white. Antennæ almost as long as body, black. Elytra wider than the thorax, black, with a not very wide white, median transverse band. Length, 7.5 mm.

Chevrolat records this species from Cuba, (Coll. Chevrolat, Gundlach and Poey), and Gundlach says "found in mountains of Trinidad, [Cuba], Mayua estate."

Our figure was drawn from a specimen kindly loaned by the Acad. Nat. Sci. Philadelphia, labeled "Cuba, Poey Coll. Dupl. 1771." It is the only specimen of this species which we have seen.

Cratomorphus Motschulsky

1852, 'Etudes Entom.,' I, p. 35

This Central and South American genus is here used to take care of *Lampyris dorsalis* Gyllenhal, a species unknown to us but which Motschulsky and later authors, if their identifications are correct, considered as belonging in the above genus. We, however, believe that there are some errors in identifications, as will be seen in our discussion under the species.

Cratomorphus dorsalis (Gyllenhal)

Lampyris dorsalis Gyllenhal, 1817, in Schönherr's 'Syn. Insect.,' I, part 3, p. 67, and appendix, p. 24.

Cratomorphus dorsalis (Gyllenhal?) Motschulsky, 1854, 'Etudes Entom.,' II, p. 34.

Cratomorphus dorsalis Gemminger and Harold, 1869, 'Catalog. Coleop.,' part 6, p. 1645. Gorham, 1880, Trans. Ent. Soc. London, p. 80; 1881, 'Biol. Cent. Americana,' (Coleoptera) III, part 2, p. 52; 1884, idem, p. 270.

Lampyris dorsalis E. Olivier, 1912, Rev. sci. du Bourbonnais, XXV, p. 34.

Oblong ovate, luteo-testaceous. Pronotum, semi-circular, with two pellucid white spots in front. Elytra brown in front. Length, half that of *Lampyris maculata* (9–10 mm. see below) Insula Bartholemy. [Translation of Gyllenhal's description.]

The species was described as *Lampyris dorsalis* by Gyllenhal and said by him to occur in "Insula Bartholemy." It was placed in the genus *Cratomorphus* by Motschulsky (1854, 'Etudes Entom.,' II, p. 34) and recorded by him as from Brazil, but Gorham considered the *dorsalis* of Motschulsky to be a different species, and E. Olivier (1910, 'Coleop. Catalog.,' part 9, p. 22) makes *dorsalis* Motschulsky a synonym of the Argentine *cossyphinus* Perty. We regret that we are unable to straighten out this somewhat complex matter but would like to call attention to the size given by Gyllenhal, who in his discussion of *dorsalis* says "*L. maculata* dimidio minor," which, according to our translation, would refer to an insect not more than 10 mm. in length, as, according to Gorham, *maculatum* Fabricius measures 7–9 lines, and a species described by De Geer under the same name is about one-third smaller. The size given by Motschulsky would refer to an insect only a little larger than given in the original description of *dorsalis*, but the specimens which Gorham, 1881, 'Biol. Cent. Americana,' (Coleoptera) III, part 2, p. 52, refers to *dorsalis* Gyllenhal are 22 to 25 mm. in length, or slightly longer than *L. maculatum*.

Photurinæ

Photuris LeConte, 1851, Proc. Acad. Nat. Sci. Philadelphia, V, p. 337.

The species of *Photuris*, owing to the head being less completely concealed by the pronotum, present a distinctive appearance, somewhat intermediate between that of Lampyridæ and Cantharidæ (Telephoridæ). They always have, however, the luminous ventral segments of the former and the same insertion of the antennæ, which are almost contiguous and between the eyes. The species are numerous in Central and South America, but none has yet been found south of Brazil. Three inhabit the United States and three are already known from the West Indies. The species have been reviewed by E. Olivier, 1886, Ann. Soc. Ent. France, (6) VI, pp. 201–246, who rejects the division into sub-

Fig. 48. *Photuris jamaicensis* Ernest Olivier, last ventral segment of male.

Fig. 49. *Photuris jamaicensis* Ernest Olivier, last ventral segment of female.

genera by Motschulsky based on the number of luminous segments, because it results in dividing the sexes of one species, but adopts a division based on the form of the claws, by which the species of the United States and those of the West Indies fall together in Section II: "Outer tarsal claw cleft in both sexes, the inner claw entire." The male has the last ventral segment sinuate laterally, ending in a linear, more or less enlarged, lobe, Fig. 48. The female has the last ventral large triangular, obtuse or slightly incised at the apex, Fig. 49.

The West Indian species may be separated by the following key.

KEY TO WEST INDIAN SPECIES OF *Photuris*

1. Elytra with paler stripes on both disk and margins.....2.
   Elytral disk unicolorous, margins sometimes paler.....3.
2. Pronotum with darker spot, generally longitudinal, and with a more or less distinct rosy hue at each side of the spot, elytral stripes definitely outlined; femora generally paler at the extreme apex.....*pennsylvanicus.*
   Spot on pronotum similar but without rosy hue at each side; elytral vittæ often indefinitely outlined; femora much darker at the extreme apex; tibiæ at apex and tarsi often dark.....*jamaicensis* (in part).
3. Elytra dark brown margined with yellow; pronotum yellow.....*brunnipennis.*
   Elytra and pronotum pale yellow.....4.
4. Pronotum pale yellow with a more or less conspicuous dark spot; legs yellow; femora dark at apex, tibiæ at apex and tarsi usually darker.
   jamaicensis (in part).
   Pronotum pale yellow, usually with a dark, large circular spot on disk; legs wholly yellow.....*livida.*

Photuris brunnipennis Jacquelin Duval

Photuris brunnipennis JACQUELIN DUVAL, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 89. GORHAM, 1880, Trans. Ent. Soc. London, p. 111. E. OLIVIER, 1886, Ann. Soc. Ent. France, (6) VI, p. 236. GUNDLACH, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 253. GORHAM, 1898, Proc. Zoöl. Soc. London, p. 320. E. OLIVIER, 1912, Rev. sci. du Bourbonnais, XXV, p. 34.

Head and prothorax yellow. Elytra brown; sides and suture bordered with yellow, which does not reach the apex. Antennæ black, with the joints paler at extreme base. Male with the head very moderately excavated between the eyes. Length, 9.8 mm.

Described by Duval from Cuba (Coll. Guérin-Méneville). Recorded as occurring throughout the island by Gundlach, and from Guantanamo by E. Olivier. We have seen specimens from the following localities in Cuba. Coll. U. S. Nat. Mus.: Cayamas, May, (E. A. Schwarz); Havana, (C. F. Baker). Coll. Amer. Mus. Nat. Hist.: La Maya,

Guantanamo, (Chas. T. Ramsden); Cabañas, Pinar del Rio, September, (C. W. Leng); Vicinity of Havana, May, (Mel. T. Cook); Santiago de Cuba.

The U. S. National Museum specimens were determined by E. Olivier.

Photuris jamaicensis E. Olivier

Photuris versicolor Gosse, 1848, Ann. Mag. Nat. Hist., (2) I, p. 268. Cited in error as *versicolor* Fabricius.

Photuris pennsylvanica Gorham, 1880, Trans. Ent. Soc. London, p. 110. Cited in error as *pennsylvanica* De Geer.

Photuris jamaicensis E. Olivier, 1886, Ann. Soc. Ent. France, (6) VI, Bulletin, p. lviii; idem, Annals, p. 235, Pl. III, fig. 10; 1907, 'Gen. Insect.,' fasc. 53, p. 58, Pl. III, fig. 12; 1912, Rev. sci. du Bourbonnais, XXV, p. 34.

Pale, testaceous above and beneath. Head not excavated between the eyes in either sex. Antennæ with each joint, in a great part, dark. Pronotum with a vague brown spot on the disk. Disk of each elytron with two brown vittæ which are sometimes well marked, but often scarcely discernible. Femora, tibiæ and tarsal joints dark at the apex. Penultimate ventral segment of the female very feebly emarginate. Length, 10–12 mm.

Confined to Jamaica. We have seen specimens from the following localities. Coll. U. S. Nat. Mus.: McCatty's Estate, Catadupa, March, (E. J. Lund); Conant Springs, April and Jamaica, (H. G. Hubbard). Coll. Acad. Nat. Sci. Philadelphia: "Jamaica." Coll. H. F. Wickham: Conant Springs, April, and Mandeville, October, (T. D. A. Cockerell). Coll. Amer. Mus. Nat. Hist.: Catadupa, March, (J. A. Grossbeck); Mandeville, November, December and January, Georges Bay, November, Montego Bay, December, Cumberland District, December, and Bath, January and February, (F. E. Watson).

While certain forms of this species are difficult to distinguish from *P. pennsylvanicus*, the majority of the specimens differ greatly, the elytral vittæ not being well defined or almost entirely obliterated in some specimens. Philip Henry Gosse 'On the Insects of Jamaica,' 1848, Ann. Mag. Nat. Hist., (2) I, p. 268, says of the fireflies of the tropics and this species in particular:

At all times the species are to be seen, fitfully gleaming by scores about the margins of woods and in open and cultivated places. It is in the woods of St. Elizabeth's, in the month of June, that I have seen the Lampyridæ in their glory; and particularly along the road leading up the mountain from Shrewsbury to Content, where it is cut through the tall forest, which overhangs it on each side, making it sombre even by day, and casting an impenetrable gloom over the scene by night. The darkness here, however, and especially at one point, a little dell, which is most obscure, is studded thick with fire-flies of various species, among which the two large ones

(*xanthophotis* and *versicolor*[1]) are conspicuous. I have delighted to watch and study their habits in this lonely spot, while the strange sounds, snorings, screeches, and ringings, of nocturnal reptiles and insects, sounds unheard by day, were coming up from every part of the deep forest around, giving an almost unearthly character to the scene. *P. xanthophotis* is seen only in flight; its light is of a rich orange colour when seen abroad, but when viewed in the light of a candle appears yellow. It is intermittent; when held in the fingers, it will frequently illuminate the antepenultimate segment of the abdomen, over which the light plays fitfully, sometimes momentarily clouded more or less, but generally saturated, as it were, with the most brilliant effulgence. This species occasionally comes in at open windows at night, but much more rarely than *P. versicolor* and the smaller kinds. *P. versicolor* is noticeable by its frequent resting on a leaf or twig in the woods, when it will gradually increase the intensity of its light until it glows like a torch; then it gradually fades to a spark and becomes quite extinct; it thus remains unseen for some time, but in about a minute, or, it may be, two, it will begin to appear, and gradually increase to its former blaze strongly reminding the beholder of a revolving light at sea. The light of this species is of a brilliant green hue. I have seen a passing *P. xanthophotis*, attracted by the glow of a stationary *P. versicolor*, fly up and play around it; when the intermingling of the green and orange rays had the same charming appearance as the two lights of *Pyrophorus noctilucus*.

Photuris pennsylvanicus (De Geer)

Lampyris pennsylvanicus De Geer, 1774, 'Mém. pour servir à l'histoire Insect.,' IV, p. 52, Pl. xvii, fig. 8; 1871, idem, German translation, p. 31, Pl. xvii, fig. 8.

This common United States species is so well known that a description outside of that given in the key to the species seems unnecessary.

It apparently occurs in the Bahamas, as we have before us one specimen from the Academy of Natural Science collection labeled "Bahamas."

Photuris livida (G. A. Olivier)

Lampyris livida G. A. Olivier, 1790, 'Entomologie,' II, No. 28, p. 24, Pl. iii, fig. 23.
Photuris livida E. Olivier, 1886, Ann. Soc. Ent. France, (6) VI, p. 230, Pl. iii, fig. 7; 1912, Rev. sci. du Bourbonnais, XXV, p. 34.

Grayish testaceous with a brownish spot on the prothorax. Length, 14 mm.

This species is mentioned as West Indian by E. Olivier and may occur there. As undeveloped specimen from Barbados in the American Museum collection approaches this species but, being immature, it does not tally in all details with the specimens from Trinidad in the U. S. National Museum collection, which were determined by E. Olivier as *livida*.

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[1]*Photuris versicolor* Fab. is a synonym of *P. pennsylvanicus* of the U. S. The only *Photuris* thus far described from Jamaica is *P. jamaicensis* E. Olivier, which is therefore presumably the species here referred to by Gosse, whose description, "a large species with drab colored elytra," is too brief to admit of definite identification. His mention of the species is not noticed in E. Olivier's review of *Photuris*, in Ann. Soc. Ent. France, 1886.

The species was described from Cayenne and may not occur north of Trinidad, the fauna of which we do not include as West Indian. There is also a species from Panama described by Gorham, 1885, 'Biol. Cent. Americana,' (Coleoptera) III, part 2, p. 273, under the name *livida*, which, according to his description, cannot refer to the species described by G. A. Olivier. The Gorham species does not seem to have been recognized by E. Olivier in any of his works on Lampyridæ.

Cantharidæ

On account of *Cantharis* Linnæus (1758) having been proposed eight years previous to *Telephorus* Schaeffer (1766), the name for the family lately known as Telephoridæ has to be based upon that of the Linnean genus.

As composed by Lacordaire, the family includes the genera, like *Phengodes*, in which the antennæ are biflabellate; these have been segregated by later authors to form a separate family Phengodidæ, and some favor including *Tytthonyx* also in that family. We have included in our treatment of the Cantharidæ the species we have assigned to *Tytthonyx*. Eight West Indian species belonging in this family had been described when we commenced our study five years ago; one has been added by Pic while our studies have been in progress; the material before us (far less complete than that representing Lycidæ and Lampyridæ) indicates seventeen more new species; and there is no doubt in our minds that still more await discovery. Our arrangement of the genera and species, which follows the studies of Lacordaire and Champion, must, therefore, be regarded as provisional, especially in its inference that all the species are congeneric with those of the mainland.

Key to Cantharid (Telephorid) Genera of West Indies

1. Elytra covering only part of abdomen ..... 2.
   Elytra entirely covering the abdomen ..... 3.
2. Last joint of palpi subsecuriform or stout; antennæ at most feebly serrate. *Belotus.*
   Last joint of palpi oval and acuminate; antennæ flattened, strongly serrate. *Tytthonyx.*
3. Mentum small, quadrate ..... 4.
   Mentum very large, wider in front ..... *Chauliognathus.*
4. Last abdominal segment bilobed, forcipiform beneath in male; head long. *Silidiscodon.*
   Last abdominal segment not bilobed ..... 5.
5. Sides of prothorax strongly incised, often lobed in male; head very short . . *Silis.*
   Sides of prothorax never lobed, at most feebly nicked or emarginate in male . . . . 6.
6. Sides of prothorax nicked in male; head short and broad ..... *Polemius.*
   Sides of prothorax not nicked; head moderately long ..... 7.

7. Antennæ inserted on frontal tubercles ..... *Tylocerus.*
Antennæ inserted directly on front of head, without intervening tubercle. *Cantharis.*

It is somewhat doubtful if any of the species described as *Cantharis* (*Telephorus*) are destitute of the frontal tubercle, but, as we have unfortunately been unable to see them all, we cannot affirm, though we suspect, that all belong to *Tylocerus*. In the above key we have given as one of the divisions separating *Tylocerus* "Sides of prothorax not nicked"; there is one species which seems to have all of the other characters of *Tylocerus* but in which the sides of the prothorax are deeply emarginate.

Belotus Gorham

Belotus Gorham, 1881, 'Biol. Cent. Americana,' (Coleoptera) III, part 2, p. 99; 1885, idem, p. 308. Champion, 1915, Trans. Ent. Soc. London, p. 134.
Lobetus LeConte, 1881, Trans. Amer. Ent. Soc., IX, pp. 58 and 59 (*nec* Kiesenwetter).

This genus, although erected by Gorham for *Lobetus abdominalis* LeConte and two Central American species, was not described by him, merely the differences in formation of the antennæ between *torticollis* and *abdominalis* being pointed out. The later description by Champion points out the principal characters on which the genus is based.

Belotus minutus, new species

Figure 50

Head and mouth-parts yellowish; sides behind the eyes darker; finely punctate and pubescent. Antennæ with the two basal joints reddish yellow; from the third on fuscous, subequal in length, slightly serrate and covered with a short whitish pubescence. Palpi with the last joint very stout, subsecuriform. Pronotum fuscous, broader than long, with a median impression; margins raised, contiguous; front slightly sinuate; hind margin straight; angles rounded. Scutellum fuscous, short, triangular, truncate at apex. Elytra fuscous, broadly dehiscent, about one-half the length of the body, finely punctate and pubescent. Underside light fuscous; legs paler; tarsi with the basal joints as long as the next three combined. Length, 2.5 mm.

Holotype, male (?), Cayamas, Cuba, (E. A. Schwarz); Coll. U. S. Nat. Mus.

Belotus antillarum, new species

Figures 51 and 51*a*

Male.—Head, thorax and scutellum yellowish red. Elytra black or brownish black, dehiscent, rounded at apex, densely pubescent with short pale hairs. Antennæ black, densely pubescent, filiform or slightly serrate; first joint twice as long as second; second, third, and fourth, increasing in length; joints five to nine equal, each longer than fourth; tenth and eleventh slightly shorter and thinner. Eyes large, black, hemispherical, prominent. Head and thorax closely and finely punctured; the latter wider than long, widest a little behind the apex. Body beneath blackish, but appearing gray from the dense pubescence; lateral margin yellow. Last abdominal segment

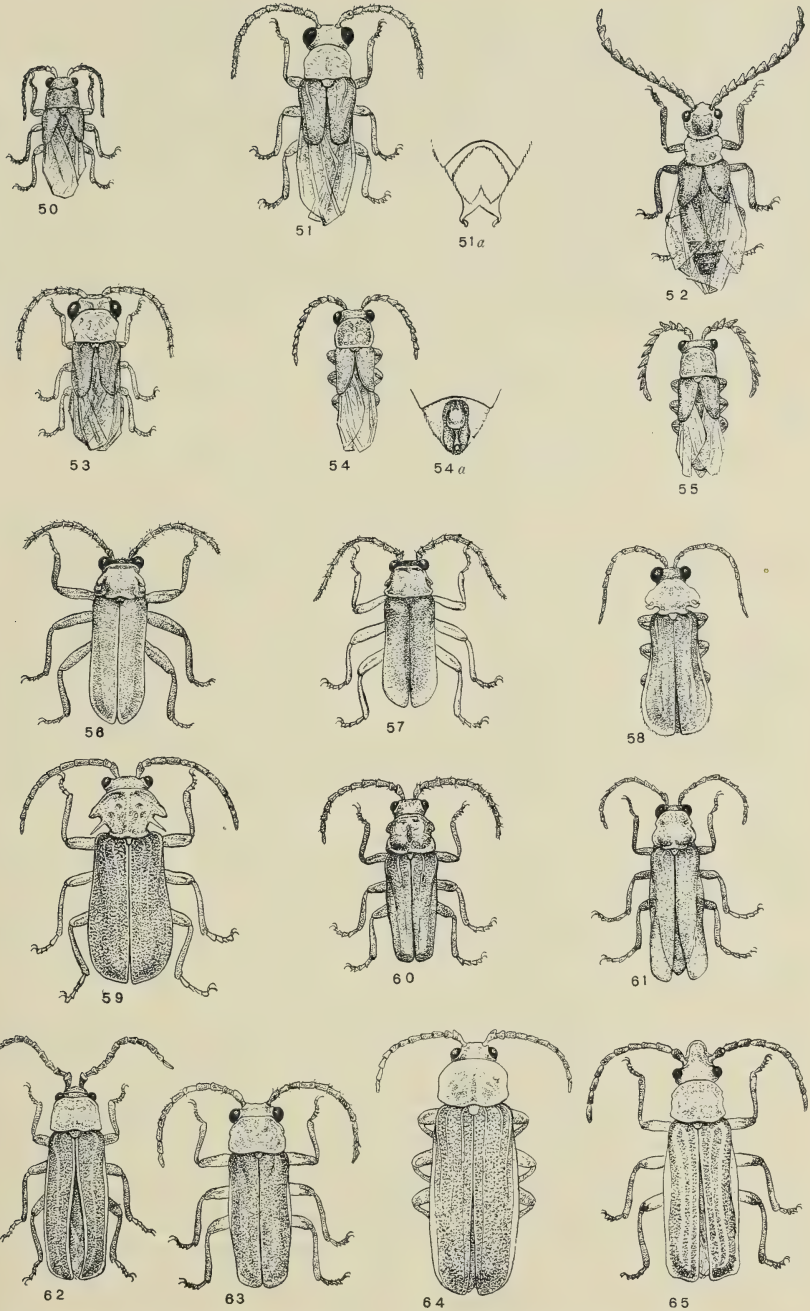

Fig. 50. *Belotus minutus*, new species, male?
Fig. 51. *Belotus antillarum*, new species, male.
Fig. 51*a*. *Belotus antillarum*, last ventral segment of male.
Fig. 52. *Belotus pallidiventris*, new species, male.
Fig. 53. *Tytthonyx cubanus*, new species, male.
Fig. 54. *Tytthonyx discolor*, new species, male.
Fig. 54*a*. *Tytthonyx discolor*, last ventral segment of male.
Fig. 55. *Tytthonyx cavicornis* new species, male.
Fig. 56. *Silis grenadensis*, new species, male?
Fig. 57. *Silis tenella* Gorham, male.
Fig. 58. *Silis marginella* Jacquelin Duval, male.
Fig. 59. *Silis* (*Haplocroscelis*) *impressa* (Pic), male.
Fig. 60. *Silidiscodon rufiventris*, new species, male.
Fig. 61. *Polemius hispaniolæ*, new species, male.
Fig. 62. *Tylocerus lineatus* Gorham, male.
Fig. 63. *Tylocerus picipennis*, new species, male.
Fig. 64. *Tylocerus coriaceus*, new species, female.
Fig. 65. *Tylocerus barberi*, new species, male.

semicircularly emarginate with, in one specimen, a glabrous wishbone-shaped organ protruding (Fig. 51*a*); in another, only the apices of the organ are seen. Legs long and slender, penultimate tarsal joint divided, claws long and bifid. Coxæ all contiguous. Length, 4–4.5 mm.

Female.—Unknown.

Holotype and one paratype: Cayamas, Cuba, February and May, (E. A. Schwarz); Coll. U. S. Nat. Mus. One paratype: No. 25136, Cayamas, Cuba, May, (E. A. Schwarz); Coll. Amer. Mus. Nat. Hist. One paratype: Poey Coll. No. 356; Coll. Acad. Nat. Sci. Philadelphia.

The last joint of the palpi is stouter than in the species we assign to *Tytthonyx* but not at all securiform.

Belotus pallidiventris, new species

Figure 52

Elongate. Yellowish, with piceous color suffusing a great part of the upper surface, especially the antennæ, thorax and elytra. Antennæ serrate, more strongly in male, blackish, paler beneath; the joints from the second on, gradually increasing in length. Head yellow beneath, brownish black above, strongly arcuately narrowed to the neck. Palpi with the last joint stout. Mandibles long, slender, toothed about the middle. Thorax broader than long, rectangular, yellow beneath, brownish black above; surface vaguely transversely channeled. Elytra about half as long as abdomen, separately rounded and feebly dehiscent at apex, yellowish; disk broadly infuscate with piceous. Upper surface feebly granulate, clothed with short black hairs. Beneath entirely pale yellow, the tibiæ and tarsi somewhat darker. Length, 3–4 mm.

Holotype male, marked "Dominica, Laiou, G. A. Ramage, 97–67;" Coll. British Mus. Allotype female, No. 24574, Laudet, Dominica, June, (F. E. Lutz); Coll. Amer. Mus. Nat. Hist.

In the male the last ventral is deeply triangularly incised, permitting, in the one before us, the yellow horny genitalia to be seen.

Belotus guadeloupensis (Fleutiaux and Sallé)

Lobetus guadeloupensis Fleutiaux and Sallé, 1889, Ann. Soc. Ent. France, (6) IX, p. 417.

Head red, wide, rounded in front. Pronotum red, transverse; feebly rounded in front, a little wider behind; posterior margin rounded; surface uneven, strongly channeled at middle, with two impressions at base. Elytra yellow, disk blackish, dehiscent, ending before the middle of the abdomen, rounded at apex. Beneath yellow. Legs yellow; apex of tibiæ smoky; last joint of tarsi black. Antennæ long, dark, indistinctly reddish at base and apex. Similar to *L. abdominalis* LeConte. Length, 4.5 mm.

Guadeloupe, Bains-Jaunes, June, (Delaney).

We have not seen any specimens of this species but have concluded that it belongs in the genus *Belotus*, as the above, which is a translation of the original description, says "similar to *L. abdominalis* LeConte."

The LeConte species was originally described as *Malthinus abdominalis* and later considered by LeConte to belong in the genus *Lobetus;* but Gorham, 1881, 'Biol. Cent. Americana,' (Coleoptera) III, part 2, p. 99, erected the genus *Belotus* of which *abdominalis* is the type species and included two other species as belonging in the genus. *B. abdominalis* seems to be the most widely distributed species in the genus, ranging from the southern United States to Panama and perhaps further southward.

Tytthonyx LeConte

1851, Proc. Acad. Nat. Sci. Philadelphia, V, p. 347

This genus has been thought heretofore to be confined to the United States, being represented by only two species. The following three species, which we are describing as new, in the collection before us extend the distribution to the West Indies.

Tytthonyx cavicornis, new species

Figure 55

Elongate. Brownish; pronotum and elytra except the apex, darker; body beneath paler; clothed above and beneath with fine, short pale hairs. Antennæ eleven-jointed; first joint stout, twice as long as second, which is a little shorter than third, none of these flattened; fourth and following joints increasingly longer and flattened, very strongly serrate, almost ramose, diminishing, however, from the eighth joint; eleventh joint elongate-oval; joints three to eight are cup-shaped at apex, deeply excavated and the slender base of each succeeding joint is attached towards the side of the cup and not at its center. Eyes moderate, round, widely separated. Head vermiculate, black behind the antennæ, brownish in front; clypeus arcuately produced; mandibles acute, not prominent. Pronotum subquadrate, truncate in front, bisinuate behind; angles rounded; sides straight; dark piceous, shining; tubercular in sculpture. Elytra about half as long as abdomen, dehiscent; rounded at tip; sculpture and coloration similar to the thorax, except that the apex of the elytra is slightly paler in color. Legs long, slender, pale, pubescent; penultimate joint of tarsi divided; claws feebly toothed. Last ventral segment of the abdomen broadly emarginate to the preceding segment, sides of emargination oblique. Length, 3 mm.

One specimen, apparently male, holotype No. 24577, Mona Island, W. I., February 26, 1914, (F. E. Lutz); Coll. Amer. Mus. Nat. Hist.

Tytthonyx cubanus, new species

Figure 53

Male.—Elongate. Head closely, finely punctate, infuscate on the occiput. Antennæ black, densely pubescent; first and second joints reddish piceous; serrate and flattened from the third joint onward. Pronotum yellow, shining, uneven; scarcely visibly punctulate, wider than long, rounded at the sides, truncate in front, feebly sinuate behind, slightly wider at base than at apex; hind angles rounded. Scutellum yellow, trapezoidal, conspicuous. Elytra dehiscent, half as long as the

abdomen, rounded at the tip, blue-black, finely pubescent above and beneath. Body beneath reddish yellow, except the tip of the abdomen which is dark; last ventral segment triangularly emarginate. Legs slender, darker than the abdomen; tibiæ and tarsi quite black, the hinder ones darker. Length, 3.75 mm.

Female.—Unknown.

Holotype and one paratype, Cayamas, Cuba, May and June, on cotton, (E. A. Schwarz); Coll. U. S. Nat. Mus. One paratype, No. 25076, Cayamas, Cuba, May, (E. A. Schwarz); Coll. Amer. Mus. Nat. Hist.

Tytthonyx discolor, new species

Figures 54 and 54*a*

Male.—Elongate; black. Front of head, thorax at sides and beneath, sides of body and the abdomen beneath, pale yellowish-white; meso- and metasternum darker and with two stripes of darker color each side. Clothed above and beneath with short, fine hair. Antennæ black, densely pubescent; joints four to nine serrate flattened; joint eight, in the type specimen before us, with a strong sinuation on outer margin; ten and eleven elongate-oval. Head as in *cavicornis* but more finely sculptured. Thorax uneven in surface, finely granulate, narrowly paler at margin. Elytra entirely black, with a faint metallic lustre, dehiscent, rounded at apex, three-fifths as long as abdomen. Legs and body beneath as in *cavicornis* except that the last ventral segment is completely divided; the penultimate segment arcuately emarginate; these two segments forming, together, an elongate cavity in which the genitalia lie (Fig. 54*a*). Length, 3.25 mm.

Holotype, No. 24575, Aibonito, Porto Rico, June 3, 1915, (Lutz and Mutchler); Coll. Amer. Mus. Nat. Hist.

With this we associate one apparently identical specimen without antennæ and four other specimens (No. 24576) from Desecheo Island, February 18, 1914, collected by F. E. Lutz, in which the eighth joint of antennæ is not sinuate and the last ventral is deeply emarginate but not divided. These specimens, apparently females, are dark brown rather than black, paler throughout. The hind coxæ are contiguous, projecting; the femur is attached to the side of the intervening trochanter, its base not quite reaching the coxa; the front coxæ are also contiguous; middle coxæ are widely separated, but the trochanter is the same in all. These specimens are also smaller, 2.5–2.75 mm. in length.

Silis Latreille

1829, in Cuvier's 'Règne Anim.,' 2 Ed., IV, p. 471

Upwards of fifty species were described under this genus by Gorham, 1880 to 1886, 'Biol. Cent. Americana,' (Coleoptera) III, part 2, from Mexico and Central America. Champion, 1915, Trans. Ent. Soc. London, pp. 16–146, Pls. III–IX, in his 'Revision of the Mexican and Central American Telephorinæ' describes several new species but places several of the already described species in the genera *Discodon*, *Polemius*, and

Ditemorphus, thereby reducing the number of recognized Mexican and Central American species of *Silis* to thirty-eight. Several species have been described from the United States and there are undoubtedly many undescribed from South America and from other parts of the world.

The genus contains a number of heterogeneous forms which, in the male, have the lateral margins of the pronotum strongly incised, the margins being lobed, lamellate, or dentate, the lobes often imbricate. The tarsal claws are not cleft and the seventh ventral segment is divided down the middle in the male.

The following species, now considered as belonging in this genus, may, with a more detailed study, be separated from it.

Silis grenadensis, new species

Figure 56

Male.—Elongate. Black, except a spot on front of head between eyes. The pronotum and a narrow marginal and sutural stripe on elytra, the latter not reaching the scutellum, yellow. Head pubescent. Pronotum deeply incised behind the middle, the incisure covered, however, by a projecting, pubescent lobe from the anterior portion, surface shining; punctuation invisible; a median impression starting at the base and not reaching the apex; also with a slight subapical impression each side of the central impression. Elytra closely granulate, pubescent, more elongate than usual. Legs long, slender, pubescent; penultimate joint of tarsi deeply bilobed; claws simple. Last dorsal segment of the abdomen, seen from above, deeply concave, the lateral edges of the concavity sharply limited; its apex is broadly emarginate, the base of the emargination squarely truncate. Length, 4.5 mm.

Female.—Unknown.

Described from one specimen loaned by the British Museum, collected by H. H. Smith, Mount Gay Estate, leeward side of Grenada.

The condition of the specimen does not admit of describing the underside.

Silis tenella Gorham

Figure 57

Silis tenella Gorham, 1898, Proc. Zoöl. Soc. London, p. 320.

Yellow, with base of head, antennæ (basal joint excepted), body (abdomen yellow margined), and elytra fuscous, the sides and apex of the latter broadly margined with yellow. Male with side margin of prothorax plicate, interrupted before the middle; hind angles acute and prominent; sides elevated into an acute tubercle in front of the incision, leaving a "neck" between the hind angle and the tubercle. Length, 4–5 mm.

Recorded by Gorham from St. Vincent, windward and leeward side, (H. H. Smith).

Figured from two specimens collected by H. H. Smith in St. Vincent, leeward side, and loaned to us by the British Museum.

Silis marginella Jacquelin Duval

Figure 58

Silis marginella Jacquelin Duval, 1857, in Ramon de la Sagra's 'Hist. Phys. Polit. et Nat. de L'île de Cuba,' Anim. Artic., p. 90. Gundlach, 1894, 'Contribucion à la Entom. Cuba,' III (?), part 4, p. 257.

Black above; brown beneath; head infuscate; scutellum and pronotum testaceous; elytra with lateral and apical margin pale white; legs brownish-testaceous, four front femora and hind knees testaceous. Pronotum transverse; that of the male slightly excised at middle of sides; armed with a large obtuse tooth, behind which the sides are strongly emarginate. Pronotum in the female broadest just behind the apical angle, indented about the middle; the apical and basal angles are broadly rounded. Length, 4.–4.7 mm.

Described by Duval from Cuba, Coll. Guérin-Méneville. Recorded from Rangel, Cuba, by Gundlach. We have seen specimens from the following Cuban localities. Coll. U. S. Nat. Mus.: Cayamas, March and June, (E. A. Schwarz). Coll. Acad. Nat. Sci. Philadelphia: Cuba, (Poey Coll. No. 147). Coll. Amer. Mus. Nat. Hist.: Solidad, June, (Barnum Brown).

Silis (**Hapalocrosilis**) **impressa** (Pic)

Figure 59

Hapalocrosilis impressus Pic, 1916, L'échange Revue Linnéene, XXII, No. 374, p. 8.

Elongate. Head, pronotum and scutellum, yellowish red, antennæ, legs and body black; elytra dark blue. Antennæ pubescent, filiform. Mandibles, long and sharp. Palpi short, equal jointed, shortly pointed at apex. Pronotum of male rounded in front with an obliquely projecting lobe at middle of side, behind which it narrows rapidly to the base and bears a long slender spine which issues from the side behind the lobe; the hind angles are also spiniform, and there is a small spine at base in front of the long one; surface shining, minutely and distantly punctured; disk with slight pubescence becoming more dense at extremity of lobes. Pronotum of female wider than long with angles broadly rounded; sides feebly sinuate, broadest at base; disk smooth and with an impression extending completely around the suture and marginal border. Elytra granulate, dark bluish metallic, pubescent, rounded at apex; suture slightly obtusely produced; side margins feebly translucent. Body beneath pubescent; last ventral segment of the abdomen with a long narrow incision, reaching nearly to its base. Legs long, slender, pubescent; first tarsal joint longest; second and third subequal; fifth somewhat long, with simple claws. Coxæ adjacent. Length, 6 mm.

We have seen specimens from the following Cuban localities. Coll. U. S. Nat. Mus.: four specimens labeled "nr. Guantanamo," (C. F. Baker). Coll. Amer. Mus. Nat. Hist.: two specimens, Guantanamo, May, (Chas. T. Ramsden). One specimen, 7 kilom. north of Viñales, September, (F. E. Lutz).

Silidiscodon, new genus

Head strongly projecting; sides behind the eyes nearly parallel; eyes somewhat protruding. Antennæ filiform. Pronotum of male arcuately emarginate at the middle, that of the female simply rounded. Apex of elytra with both sutural and lateral angles rounded. Legs long, slender; the front tibiæ of the male provided with a stout long claw; penultimate tarsal joint divided; claws simple. Male with the last abdominal segment inflated and divided beneath; excavate above. Female with a cup-shaped depression between swollen sides.

Similar in appearance to *Silis* but can be readily separated from that genus by the strongly projecting head and by the bilobed forcipiform last abdominal segment in the male. It also approaches the genus *Discodon*, but the simple tarsal claws alone would be sufficient reason to separate it from that genus.

Silidiscodon rufiventris, new species

Figure 60

Elongate. Head, pronotum and elytra, bluish black; beneath entirely red; antennæ from second joint, the tibiæ, tarsi and the mesosternum bluish black, the blue shade being less evident than on the elytra. Head pubescent, more thickly at the sides. Antennæ filiform, pubescent. Pronotum of male arcuately emarginate at the middle, with an obtuse tubercle in front of the emargination; simply rounded in the female, shining, pubescent, very closely, but minutely punctured; hind angles broadly rounded, nearly quadrate. Elytra finely granulate, rounded at apex, finely clothed with yellow pubescence. Legs long, slender, pubescent. The front tibiæ of the male is provided with a stout, long claw, conspicuous from its size and black color; penultimate joint of the tarsi divided; claws simple. Last abdominal segment of the male inflated, divided beneath, excavate above; provided in the female with a cup-shaped depression between swollen sides. Length, male, 4 mm; female, 5 mm.

Holotype male and allotype female, collected April 13, 1913, by W. V. Tower, at Romana, Dominican Republic; Coll. U. S. Nat. Mus.

Polemius LeConte

1851, Proc. Acad. Nat. Sci. Philadelphia, V, p. 338

The following species, which we are describing as new, is the first record, as far as we know, of this genus being found in the West Indies.

Polemius hispaniolæ, new species

Figure 61

Elongate, reddish. Head finely punctate and pubescent, with a vague transverse impression between the eyes; eyes round and moderately prominent. Antennæ black, feebly serrate, first joint yellowish red; second joint less than half as long as the third; outer joints flattened, densely pubescent. Pronotum yellowish red, wider than long; front angles rounded; surface shining, uneven, not visibly punctured; covered with short, pale pubescence intermixed with a few darker hairs; female with hind angles acute, sides rounded, feebly sinuate in front of middle; male with hind angles prolonged obliquely backwards; sides with an incision before the middle; margins orna-

mented with long hairs. Elytra dark bluish-violet, basal two-thirds of the outer margin narrowly bordered with yellow, granulate, rounded at apex. Legs long, slender, pubescent; tarsal claws simple. Underside of male yellowish brown with abdominal segments darker and with last abdominal cleft to base. Legs brown. Underside of female yellowish red; apex of femora, the tibiæ and tarsi dark brown. Length, 6 mm.

Holotype male, allotype female, and ten female paratypes: San Francisco Mts., Dominican Republic, August and September, (Aug. Busck); Coll. U. S. Nat. Mus. Eight paratypes: female, No. 24578, Sanchez, Dominican Republic, (F. E. Watson); Coll. Amer. Mus. Nat. Hist.

Tylocerus Dalman

1823, 'Analecta Entomologica,' p. 57

This genus was erected by Dalman for the species *crassicornis*. A translation of the description of the genus and species will be found under *Tylocerus crassicornis*.

Tylocerus crassicornis Dalman

Telephorus (*Tylocerus*) *crassicornis* Dalman, 1823, 'Analecta Entomologica,' p. 57.

A translation of Dalman's description is as follows:

Fuscous; head and thorax flavo-testaceous; antennæ clavate; fuscous; basal joint large, incrassate luteous.

Habitat in Jamaica, Mr. Forsström, Mus. D. Paykull.

Length, 5 lines.—A species similar to *Telephorus fuscus* (*Cantharis fuscus* Fabr.) but from that genus it differs distinctly in the peculiar form of the antennæ, wherefore in the collection we have made for it a special subgenus called *Tylocerus*.

Antennæ nearly as long as the body, slightly thickened; basal joint large, oval, yellow; the following obconical, gradually increasing in size; apical joint large, sublinear, of the length of the first joint, apex cone-shaped. Head depressed, luteous, immaculate; palpi fuscous. Eyes small, black, orbiculate, prominent. Thorax shorter than the head, transverse, subquadrangular, with entire margins strongly reflexed; anterior angles rounded; posterior straight, subprominent; above bicallous, smooth, yellow, immaculate. Scutellum semioval, testaceous. Elytra scarcely wider than the thorax, linear, rounded at apex, depressed, smooth, fuscous; lateral margins white; dorsal costæ obsolete. Body beneath fuscous, same color as elytra. Legs slender, of the same shape as in the other species of the genus. Anterior ones lutescent at the base.

We have not seen any specimens of this species. Dalman in his description gives Jamaica as the type locality, and later Lacordaire, 1857, 'Genera Coléop,' IV, p. 348, under his remarks on the genus *Tylocerus*, has appended the note, "*T. crassicornis*, Dalm. *loc. cit.*; l'examplaire de Dalman provenait de la Jamaique; celui que j'ai sous les yeux et qui correspond exactment à la description de cet auteur, est de l'îsle St. Barthélemy." It does not seem plausible that a species should be found in two islands as widely separated as Jamaica and St.

Bartholomew, with no records of it having been found in any of the intervening islands. For this reason, we have looked up records credited as "Dom. Forsström" and have found records from St. Bartholomew and Guadeloupe, but have found only the above Jamaican record.

There are also no records of this species being found in Jamaica, although extensive collecting has been carried on in the island. It is also remarkable that in the number of species recorded from Jamaica, this is the only one which is not represented by one or more specimens in the collections before us. With this combination of facts we are led to believe that the locality cited in the original description is erroneous and the type locality should be St. Bartholomew Island.

Tylocerus lineatus Gorham

Figure 62

Tylocerus lineatus Gorham, 1898, Proc. Zoöl. Soc. London, p. 320, Pl. xxvii, fig. 1.

Blackish fuscous, subopaque, with head and thorax orange. Thorax transverse. Head between the eyes black above, with median basal yellow line. Coxæ and trochanters pale yellow. Elytra blackish-fuscous with the suture, lateral and apical margin and a costa extending from humerus nearly to apex white. Scutellum yellow. Males with longer antennæ, the basal joint very large, inflated nearly as long as the next three, sixth ventral segment split. Length, 7–9 mm.

We have seen specimens from the leeward side of St. Vincent and from Balthazar, Mt. Gay, Grenada, (H. H. Smith); Coll. British Mus.

The specimens from Grenada and St. Vincent, loaned to us by the British Museum, agree with the description by Gorham.

Tylocerus lineatus dominicus, new variety

Head smoky black, excepting around the base of antennæ and the basal margin. Femora yellow, darker at apex, tibiæ and tarsi brown, otherwise as in the typical form. Length, 7.5–9.5 mm.

Known only from Dominica. Holotype male, No. 24595, Portsmouth, June, (R. W. Miner). Allotype female, No. 24596, Long Ditton, June, (F. E. Lutz). Paratypes, Nos. 24597–24599 inclusive, Portsmouth, June, (R. W. Miner); Long Ditton and Roseau, June, (F. E. Lutz); and one without definite locality in Dominica. The above are in the Coll. Amer. Mus. Nat. Hist. There are also the following paratypes. Coll. U. S. Nat. Mus.: Dominica, June and July, (H. W. Foote, Yale Exped., 1913); Dominica, (A. H. Verrill). Coll. British Mus.: Castle Bruce, Lawn, (G. A. Ramage), Dominica, (H. A. Nicholls).

We have seen twenty-nine specimens of this new variety. In some of the specimens the femora and tibiæ are quite pale in color, with only the tarsi darker, but in most specimens the femora, tarsi, and apices of the tibiæ are darker. There is also a tendency of the white dorsal stripe to broaden out at the base, but in all of the specimens this stripe is

better marked in this variety than in the specimens of the typical form which are before us.

The antennæ are the same as in the typical form, that of the male being longer and with the basal joint long and swollen. The females have all of the joints shorter and thinner than in the male.

Tylocerus lineatus melanicus, new variety

Head, palpi, mandibles, thorax, scutellum, mesosternum, coxæ and trochanters black, otherwise as in the typical form. Length, 9 mm.

Holotype female, Dominica, November, (A. F. Porter); Coll. H. F. Wickham. Paratype female, Dominica, "June–July," (H. W. Foote, Yale Exped., 1913); Coll. U. S. Nat. Mus.

This may be merely a melanic form of the species but we think it deserving of a varietal name, unless some convincing proofs can show a closer connection between it and the typical form. A male in the Coll. U. S. Nat. Mus. has the same data as the paratype female but is too badly damaged to permit description.

Tylocerus picipennis, new species

Figure 63

Male.—Elongate; yellowish. Antennæ, base of femora, the tibiæ, tarsi and elytra blackish. Antennæ with first joint enlarged, twice as long as the second joint which is about equal to the third, succeeding joints each a little longer, all pubescent. Head channeled between the antennæ, alutaceous; eyes rounded, moderately prominent. Pronotum wider than long; sides nearly straight; angles rounded; explanate and reflexed in front, sinuate behind; uneven and alutaceous on the disk. Elytra very feebly granulate, vaguely costate, rounded at apex. Beneath entirely pale; coxæ very prominent, adjacent, separated slightly from the femora by the short, stout trochanters which are attached at their sides to the femora; legs long and slender; tarsi with penultimate joint divided; claws simple; last ventral segment of abdomen deeply triangularly emarginate; penultimate segment also emarginate but less deeply. Length, 8 mm.

Female.—Unknown.

Represented by one specimen, holotype, Montserrat, March 19; Coll. U. S. Nat. Mus.

A very pale specimen from Santa Lucia, June, 1889, (G. A. Ramage), Coll. British Mus., with the piceous color exhibited only in a vitta on the elytra shows no differences structurally and may be an immature example of this species.

Tylocerus coriaceus, new species

Figure 64

Female.—Elongate; yellowish. Antennæ and disk of elytra piceous. Antennæ with first joint obconical, pale at base; second joint globular, one-third as long as the third joint, succeeding joints increasing in length, not flattened, pubescent. Head with an arcuate transverse impression between the eyes, in front of which the surface

is depressed, finely punctulate; eyes rounded, moderately prominent. Pronotum as in *picipennis* but with a fine median impressed line, reaching neither apex nor base. Elytra leathery in appearance, finely granulate, vaguely costate; side margins, suture and apex margined with paler color, more broadly on the suture near the scutellum; broadly rounded at apex. Beneath as in *picipennis* but with each abdominal segment deeply longitudinally creased at middle. Length, 9 mm.

One specimen, holotype, No. 24579, Sanchez, Dominican Republic, June, 1915, (F. E. Watson); Coll. Amer. Mus. Nat. Hist.

Tylocerus barberi, new species

Figure 65

Elongate, yellow. Head yellow; mandibles brown at apex; palpi brown. Antennæ pubescent with an intermixture of longer hairs; brown with basal end of each joint yellow. Pronotum yellow, subquadrate; front angles broadly rounded; hind angles narrowly rounded; margins somewhat broadly reflexed; disk with median part impressed, this with the reflexed margins making the disk appear as if having a raised bump at each side. Scutellum yellow, subtriangular, apex rounded. Elytra blackish brown, covered with short, yellow pubescence; margins yellow; disk with two narrow yellow stripes beginning at the base, where they are sometimes joined and extending to near the apex at which point they may join, or the one nearer the suture may be shorter (in some specimens it is very faint and cannot be distinguished beyond the basal half of the elytra). Underside yellow; femora yellow, apical tip dark brown; tibia yellow, apical part darker. Tarsi brown, with apical part of each joint slightly paler. Length, 7.5–9.5 mm.

Male.—Antennæ about two-thirds the length of body; basal joint large club-shaped.

Female.—Antennæ less than one-half the length of the body, basal joint club-shaped but much smaller than in the male.

Holotype male, No. 24580, and allotype female, No. 24581, Manati, Porto Rico, June; Coll. Amer. Mus. Nat. Hist. Paratypes Nos. 24582 to 24587: Manati, Aibonito and Adjuntas, June, (Lutz and Mutchler); Aibonito, June, and Coamo Springs, July, (H. G. Barber); Coamo Springs, December and January, (H. E. Crampton); Santa Rita, July, (E. G. Smyth); Mayaguez, April, (R. H. Van Zwaluwenburg); Coll. Amer. Mus. Nat. Hist. Paratypes in Coll. U. S. Nat. Mus.: El Yunque, February, (C. W. Richmond), March, (L. Steineger); Adjuntas, April, (L. Steineger); Bayamon and Mayaguez, January, (Aug. Busck). Paratypes in Coll. Porto Rico Agric. Exp. Sta.: Rio Piedras, (T. H. Jones).

Most of the specimens in the American Museum collection were collected at light, those from Aibonito being from a large tobacco plantation, where a powerful gasoline lamp was used. In Manati and Adjuntas an auto head-light was used to attract the insects.

According to the description of *Telephorus maculicornis*, the markings of the antennæ and legs are very similar to those in *barberi*, but in *Tylocerus barberi* the elytra are nearly black, narrowly margined with yellow and with two narrow, yellow, longitudinal lines on the disk, dividing the black color into three broad vittæ, the two sutural ones being of about the same width, and the outer one about as wide as the other two

combined. According to the description, the elytra of *T. maculicornis* are yellow with two narrow black vittæ.

Our species is undoubtedly a *Tylocerus* and distinct from *maculicornis*, but this latter species also seems to us, from description, to belong in the genus *Tylocerus*.

We take pleasure in dedicating this species to our friends and colleagues, Herbert S. Barber of Washington and Harry G. Barber of New York.

Tylocerus cinctipennis (Fleutiaux and Sallé)

Telephorus cinctipennis Fleutiaux and Sallé, 1889, Ann. Soc. Ent. France, (6) IX, p. 416.

Reddish. A triangular black spot on head. Elytra bluish black; narrowly bordered with yellow; beneath yellow. Abdomen and half of tibiæ, blackish. Antennæ blackish, first joint yellow. Head short, rounded, channeled. Thorax twice as wide as long, surface uneven, two elevations on the disk. Elytra a little wider than thorax. Length, 6 mm. Guadeloupe, Camp Jacob, April; Bains-Jaunes, June, (Delauney).

Variety *propinquus* Fleutiaux, *loc. cit.*, p. 417

Same size, a little more robust and a little paler red. Elytra more widely bordered with yellow, especially in front; disk black without bluish reflection. First joint of antennæ sometimes black and legs black with only front femora and half the middle femora yellow. Guadeloupe, Bains-Jaunes (Delauney); Gourbeyre (Vitrac).

We have not seen representatives of the species or variety, the above being a free translation of the original descriptions.

Tylocerus maculicornis (Fleutiaux and Sallé)

Telephorus maculicornis Fleutiaux and Sallé, 1889, Ann. Soc. Ent. France, (6) IX, p. 416.

A translation of the original description of this species is as follows.

Length, 8 mm.—Pale yellow. Head and pronotum somewhat reddish. Head protruding (projecting), rounded anteriorly; a little excavation on the vertex; apex of the mandibles red; terminal joint of the palpi pointed (acuminate); flattened and rounded within. Antennæ approximated at the base, inserted between the eyes, black, with the base of all the joints yellow. Pronotum transverse, rounded anteriorly, straight and raised on the sides, a little emarginate posteriorly; anterior angles curved downward; posterior angles emarginate; surface uneven, provided with two protuberances placed transversely. Scutellum narrowed and rounded behind. Elytræ pale yellow, provided each with two blackish, longitudinal, narrow bands which unite before the apex. Underside of the body and legs pale yellow, knees black, tarsi brownish, the base of their joints and claws yellow. Camp Jacob, July; Bains-Jaunes (Del.); Gourbeyre, Petit-Bourg, Trois-Rivières, in the axils of leaves of the large Aroideæ (Vit.).

Not seen by us, but we believe that this and the preceding species should be placed under the genus *Tylocerus*.

Tylocerus violaceus, new species

Elongate, black. Elytra deep violet-blue. Antennæ filiform, pubescent; second joint one-third as long as the third, succeeding joints slightly longer. Head punctate; eyes rounded. Thorax transverse; angles rounded; sides oblique in apical third, straight behind; surface alutaceous, not very closely punctate, uneven, with a median basal impression. Elytra vaguely subcostate, feebly granulate, sparsely covered with a short pale pubescence. Legs moderately long, pubescent. Length, 4.5 mm.

Described from one specimen labeled "Jamaica," in Coll. British Museum.

Tylocerus depressicollis, new species

Female.—Elongate, piceous. Head and thorax yellow. Elytra with a bluish lustre. Antennæ with first joint long; second about one-fourth as long as the third; succeeding joints longer, pubescent. Head punctulate; eyes rounded, large. Thorax transverse, angles rounded, sides deeply emarginate at middle, disk with a large oval depression, sharply defined behind and laterally, but level with the apex in front; surface uneven; side margins reflexed; punctuation scarcely visible; pubescence short, yellow, barely noticeable. Scutellum small, yellow; apex broadly rounded. Elytra vaguely subcostate, scarcely granulate, covered with a fine, very short, yellow pubescence; apex rounded. Legs long, slender; penultimate joint of tarsi divided; claws simple; the last ventral segment of the abdomen acutely incised. Length, 5 mm.

Male.—Unknown.

One specimen, Jamaica, (H. G. Hubbard); Coll. U. S. Nat. Mus.

The reference of this species of *Tylocerus* is doubtful. It possesses the frontal tubercles that characterize that genus, but its emarginate prothoracic margin and subsecuriform palpi suggest a position closer to *Silis*.

Chauliognathus Hentz

1830, Trans. Amer. Philos. Soc., N. S., III, p. 460

It seems well to repeat here the remarks by Champion, 1914, Trans. Ent. Soc. London, p. 134, regarding this genus:

Chauliognathus includes a large number of American forms, the species from New Guinea and Australia referred to it by Bourgeois and Pic probably require a separate genus for their reception. It is apparently replaced in the Antilles by *Tylocerus*.

The following species can hardly be considered West Indian. It seems to have reached the Bahamas from the United States.

Chauliognathus marginatus (Fabricius)

Cantharis marginatus Fabricius, 1775, 'Syst. Entom.,' p. 206.

This widely distributed North American species is so well known that the bibliography and description seems unnecessary. The admission of the species in this paper as West Indian is based on a record of Otto Lugger, 1888, Proc. Ent. Soc. Washington, I, p. 57, who records it from the island of Abaca, one of the Bahamas.

59.7(85)

Article IX.—ON A COLLECTION OF MARINE FISHES FROM PERU

By John Treadwell Nichols and Robert Cushman Murphy

Plates XXV and XXVI

INTRODUCTION

The latest monographic work on Peruvian ichthyology, 'The Fishes of the West Coast of Peru and the Titicaca Basin,' by B. W. Evermann and Lewis Radcliffe, was issued in 1917 as Bulletin 95 of the United States National Museum. The paper is based principally upon collections made during 1907 and 1908 by Dr. Robert E. Coker, but it purports to list all species which had been recorded from the Pacific coast and drainage of Peru up to the time of its publication. The marine fishes in the list number 152 species, of which two or three are said to be doubtful.

The present contribution is based upon incidental collecting by the junior author between October 1919 and January 1920 at points along the Peruvian coast between Independencia Bay (14° 18′ S.) and Lobos de Tierra Island (6° 23′ S.). Only 64 species are represented by specimens, but the wealth of the littoral ichthyofauna is indicated by the fact that two of these have proved to be new to science, while eight additional species are recorded for the first time from Peruvian waters. We have carefully followed Evermann and Radcliffe's systematic arrangement and nomenclature, in order to make our contribution a convenient supplement to their more comprehensive paper.

The following species are herein described as new:

Neomænis peru
Sebastodes chincha

The following species constitute additions to previous lists:

Carcharhinus limbatus
Cypselurus californicus
Eurystole eriarcha
Mugil thoburni
Hippocampus ingens
Germo argentivittatus
Xenistius californiensis
Spheroides lobatus

Aside from these, a common sting-ray, *Dasyatis brevis*, jaws and a spine of which were brought back with the present collection, was described from Peru by Garman, but the record was evidently overlooked by Evermann and Radcliffe.

The Peruvian *Trachurus*, though long known, has always been confused with extralimital species, until recently described on material from this collection as *Trachurus murphyi*.[1]

[1]Nichols, J. T., 1920, Bull. Amer. Mus. Nat. Hist., XLII, p. 479.

The present paper, therefore, brings the total number of salt-water fishes known from the Peruvian coast up to 163 species. Beyond a doubt, many additions will be made in the future, not only through the discovery of undescribed or obscure species but also from among widely distributed pelagic or littoral fishes such as, for example, the "dorado" (*Coryphæna*) and the "pejesierra" (*Pristis*), both of which are apparently familiar to the native fishermen, even though no Peruvian specimens have yet fallen into the hands of a naturalist.

Peruvian Fish Names

A careful field-record of the names by which native fishes are known to the Peruvian Indian fishermen was kept by the junior author, and a subsequent comparison of these with longer lists of names collected by Dr. Coker more than a decade earlier reveals a noteworthy agreement which implies a relatively fixed vernacular nomenclature. The names supplied by Dr. Coker for the paper by Evermann and Radcliffe are now, of course, definitely associated with the technical terminology, and the same is true of the majority of native names used in the taxonomic section of the present work. But a larger number of other Peruvian fish names, including doubtless many synonyms and localisms, are still not exactly determinable, and we believe that an attempt to allocate these, even though the list be tentative and far from complete, will not only aid future scientific investigators but may also become of use to the organizers of the great fishing industries which are certain to be developed, sooner or later, along the coast of Peru.

The names listed were derived from the sources mentioned above and also from papers by Dr. Coker published in the Boletin del Ministerio de Fomento, Lima, Peru, volumes V (1907) to VII (1908). To the author of these papers the credit for many of the determinations must also be given. The list, which should be considered as characteristic though by no means complete, lends itself to analysis into terms of three classes, as follows.

1.—Old Spanish names, chiefly of Mediterranean fishes, which have been generally reapplied in Hispanic America.

2.—Words of Spanish-American origin, many of which are metaphorical, e. g., "cruz" (cross) for *Sphyrna zygæna*, "ojo de uva" (grape-eye) for *Hemilutjanus macrophthalmos*, "pintadilla" (painted) for *Cheilodactylus variegatus*. In other instances the significance of the name is fanciful or entirely obscure, e. g., "ayanque" (jackstay) for *Sciæna deliciosa*, a term which may, however, be a corruption of "arenque"

(herring). This group includes many names which have spread to the coast of Peru from the Antilles, particularly from Cuba. Among these are "pámpano" and "jerguilla."

3.—Ancient Peruvian names of the Quichua and other Indian tongues. Doubtless many terms of which we have been unable to determine the source and primary meaning belong here.

In accordance with the genius of the language, diminutive forms are much in evidence. Such names may have come to replace the nouns from which they were originally derived, as "mojarilla," "chabelico"; or they may refer to young or small-sized examples of familiar fishes. Examples of diminutives applied in the latter sense are "ayanquito," "jurelcito," "lisita," "camotilla," "robalito," "cochinillo," "borrachin.

The Old World Spanish names mentioned in the first group above are worthy of separate citation, for most of them refer to Peruvian representatives of types of fishes common in the Mediterranean or in the streams and lakes of Spain. These alone are listed below, purely local names, as well as universal Spanish group names, such as "tiburones" (sharks) being omitted.

Name	Literal or Primary Meaning	English Vernacular Equivalent
Aguja	Needle	Barracudas, needlefish and pipefish
Albacora	Albacore	Albacore or tunny
Angelote	Figure of an angel	Angel-fish (*Squatina*)
Anguila	Eel	Eel
Bagre	Catfish	Catfish
Barbudo	Bearded	Threadfin
Bonito	Pretty	Bonito
Caballa	Mare	Mackerel
Cabrilla	Kid	Sea-bass
Cazón	Chaser, hunter	Shark
Cochino	Pig	Trigger-fish
Corvina	Resembling a crow	Corbina
Dorado	Gilded	Dolphin (*Coryphæna*)
Jurel	Scad	Scad
Lenguado	Tongue-shaped	Flounder
Lisa	Mullet	Mullet
Marrajo	Morocco (?)	Some species of large shark
Mojarilla	Little mojarra	A kind of croaker (*Stellifer*)
Morena	Moray	Moray
Peje-espada	Swordfish	Swordfish
Pejerrey	Kingfish	Silverside (*Atherinidæ*)
Pejesapo	Toadfish	Clingfish
Raya	Ray	Ray or skate

Name	Literal or Primary Meaning	English Vernacular Equivalent
Robalo	Robalo	A species of croaker (*Sciæna starksi*); not "robalo" of the Spanish Main (*Centropomus*)
Roncador	Snorer	One of the grunt family (*Brachydeuterus leuciscus*).
Sardina	Sardine	A kind of herring (*Sardinella*)
Sargo	Sea-bream	Used in Peru for a fish of the grunt family (*Anisotremus scapularis*).
Sierra	Saw	Sierra (*Scomberomorus*) Sawfish (*Pristis*)
Tollo	Tope, dogfish	Dogfish
Volador	A flyer	Flyingfish

ANNOTATED LIST OF COLLECTED MATERIAL[1]

Gyropleurodus peruanus Evermann and Radcliffe. "Gato." Lobos de Afuera Island, January 5, 1920. Washed ashore in dying condition.

Carcharhinus limbatus (Mueller and Henle). "Cazón." Jaws of this shark taken at Lobos de Tierra Island and presented by an Indian fisherman at the island on January 9, 1920.

Sphyrna zygæna (Linnæus). "Cruz." Observed both at sea and in Indian fishing communities at Lobos de Tierra. Valued for food. No specimens preserved.

Mustelus abbotti Evermann and Radcliffe. "Tollo." Callao market, December, 1919.

Mustelus dorsalis Gill. "Tollo." Callao market, December 24, 1919.

Rhinobatus planiceps Garman. "Guitarra." Caught from dock at Pacasmayo, January 2, 1920.

Dasyatis brevis (Garman). "Raya." Jaws and spine of two specimens, Paracas Bay, October, 1919. Common wherever there are shallow quiet bays along the coast, such as Paracas Bay south of Pisco. Numerous fishermen were seen who had been wounded by sting-rays, and an instance cited where a swimmer struck in the breast was unable to reach shore and so drowned.

Potamalosa notacanthoides (Steindachner). "Machete." Pisco Bay, near Isla Blanca, November 22, 1919.

Sardinella sagax (Jenyns). "Sardina." One from stomach of a female sea lion (*Otaria byronia*), Chincha Islands, October 14, 1919. Three specimens, Chincha Islands, October 26, 1919.

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[1]One specimen of each, except where otherwise noted.

The schools of this species are pursued by the sea lion of the coast, for which the sardina is apparently a favorite and selected food supply.

With reference to mixed schools of fishes, chiefly sardinas, cojinobas, caballas, and jurels, which played about the dock of Central Chincha Island in October 1919 (cf. p. 507), the junior author has recorded the following notes:

October 14. Presently a lobo [sea lion] appeared, and glided around beneath the dock, making a clear path over and over again through the groups of fish in which cojinobas were the most numerous. The fishes would dart aside with alacrity when the sea lion appeared, but they calmed down as soon as their enemy had passed, and there was no tendency toward deserting the locality. Time and time again, the lobo would shoot among the fish and take toll, but the reaction of the prey, both individually and collectively, was always the same—a momentary start of two or three feet, and then a return to lethargy.

Shortly before dark, the lobo, grown careless through luxury, hauled out on the beach below the house, where it was shot. The complete contents of its stomach was as follows: 17 sardinas, 2 caballas, 2 cojinobas, 1 jurel, 3 remains of fishes probably of the species listed, 3 stones of about 1½ inch diameter, and numerous parasitic worms.[1]

Engraulis ringens Jenyns. "Anchoveta." A number of specimens from fishermen at Pescadores Islands, off Ancon, December 13, 1919. Noted at all points along the coast.

During the afternoon of February 2, 1920, while on board a steamer off Huarmey, I estimated that a hundred shoals of anchovetas were within sight. At times, when the bonitos attacked them from beneath, large areas of the surface would be so broken by the leaping of the little fishes that the ocean hissed as though a deluge of rain were descending upon it. The most remarkable sight of all was the manner in which whole herds of lobos [sea lions] were lolling and frolicking among the anchovetas, gorging themselves to the limit of their capacity.

On other occasions I have had the good fortune to run directly over schools of anchovetas in a launch of shallow draft. Their appearance from above is amazing, for the quivering, silvery creatures seem to be packed together like sardines in a tin, except that their heads point all in one direction as their legion, which somehow seems more like an individual organism than a conglomeration of millions, streams through the gauntlet of its diverse and ubiquitous enemies (pp. 65, 66[2]).

Ophichthus callaënsis (Guenther). "Anguila." Found dead on sandy beach, head of Independencia Bay, November 18, 1919.

Gymnothorax wieneri Sauvage. "Morena." One from Lobos de Tierra Island, January 6, 1920; one from dock at Pacasmayo, January 3, 1920; one from Lobos de Tierra Island, January 14, 1920.

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[1]Murphy, field note.
[2]Murphy, R. C., 1922, 'Peruvian Fisheries,' Brooklyn Museum Quarterly, IX, No. 1, pp. 44–70.

Galeichthys peruvianus Luetken. "Bagre." One seined from sandy beach, North Chincha Island, November 23, 1919; and one from Callao market, December, 1919.

Tylosurus stolzmanni (Steindachner). One from pelican stomach, Lobos de Tierra Island, January, 1920.

Cypselurus californicus (Cooper). "Volador." Central Chincha Island, November 11, 1919. A single specimen about a foot long washed ashore in dying condition. More material may make it possible to separate this from the Californian fish. The only differences we find are somewhat shorter pectoral and longer ventral, 1.4 and 3.3, respectively, in length to base of caudal.

Eurystole eriarcha (Jordan and Gilbert). Nine specimens seined from beach of North Chincha Island, November 24, 1919; as many seined at same place, November 23, 1919.

Basilichthys affinis (Steindachner). "Pejerrey." A number of specimens, Lobos de Tierra Island, head of Independencia Bay, North Chincha Island, and Callao market.

Mugil cephalus Linnæus. "Lisa." From fishing boat south of Paracas Peninsula, November 19, 1919. Mullets about a foot long were seen on the ground in the colonies of breeding pelicans. One of about 18 inches, center of Santa Rosita Id., could scarcely have been anything but *cephalus*.

Mugil thoburni Jordan and Starks. "Lisa." Several from lagoon of Paracas Bay, October 19, 1919, and November 10, 1919. Small mullet are exceedingly abundant in the shallow lagoons where they are often left stranded by the retreating tide.

Sphyræna idiastes Heller and Snodgrass. "Aguja," "Picuda." Lobos de Tierra Island, January 10, 1920.

Siphostoma aciculare (Jenyns). Native name not recorded in notes; Coker gives "aguja." Washed ashore on Central Chincha Island, October 13, 1919.

Hippocampus ingens Girard. "Caballito." Dried specimen taken at Lobos de Tierra Island about December, 1919, and presented by an Indian fisherman at the island on January 8, 1920. There is no reason to doubt that this specimen was actually taken at Lobos de Tierra.

Scomber japonicus Houttuyn. "Caballa." Several specimens, Chincha Islands, and Pescadores Islands off Ancon.

Sarda chilensis (Cuvier and Valenciennes). "Bonito." Two specimens purchased at the water-front market, Callao, December 24, 1919.

"One evening in late October the launch entered the strait of the Chinchas after dark, its course a blaze of phosphorescence. The bonitos

were foraging, and their erratic, zig-zag wakes were also marked in fiery lines. It gave one a new impression of the speed with which these fish move and of the extreme irregularity of their course." (Murphy, field note.)

Germo argentivittatus (Cuvier and Valenciennes). "Albacora." We identify the photograph of a tunny taken between Lobos de Tierra and Lobos de Afuera as this species. In the type description *argentivittatus* was credited to the Atlantic, but also mentioned from the Indian Ocean (Dussumier). Our photograph agrees with the description and also with notes made on a specimen labelled Malabar, Dussumier, which was examined by the senior author in the Paris Museum some years ago. Day does not list the species in 'Fauna British India, Fishes,' and there may be some error in the localities to which it has been assigned. This species has the lower parts very beautifully and regularly marked with vertical white or silvery stripes and rows of oval spots in alternation. For the rest, it is somewhat intermediate between typical *Thunnus* and the albacores (*Germo*), having a breast fin more elongate than in any true tuna, though not so abnormally long as in other species of albacores.

Neptomenus crassus Starks. "Cojinova." A small specimen from the shelter of a large jellyfish, Central Chincha Island, October 23, 1919. Two large specimens from Pescadores Islands, off Ancon, December 13, 1919, and Central Chincha Island, October 27, 1919.

The following notes by the junior author refer to the abundance of this species.

Owing to the abundance of Peruvian marine fishes which travel in dense schools, the *fisga* or gig is often an effective instrument in the hands of the fishermen. In late afternoon at the Chincha Islands, when the guano workmen had ceased their toil and the day wind had died down, the Indians used to congregate upon the mole of Central Island, for the purpose of striking gigs into the masses of fish which oscillated in the swells below. I remember many quiet October evenings in 1919 when, during the hour before sunset, vast shoals composed mostly of four species—herrings, mackerels, cojinobas, and scads—filled the shallow water near the shores of the Chinchas. All the fish were of about the same length, nine or ten inches, and, although the cojinobas appeared to be the most numerous, the four species mingled rather indiscriminately, for a single thrust would often bring up several kinds together. It was necessary only to wait until well bunched groups had gathered below, and then to hurl the Neptunic *fisga*. When it was drawn out by its lanyard, the steel fork would usually have two or three, or sometimes more, silvery fish transfixed by the prongs. While some of the Indians were cheerily casting the gig, others were scarcely less successful with a curious contrivance consisting merely of a weighted line with many hooks attached to it at intervals of a few inches. The line would be lowered gently to the bottom; at the

opportune moment it would be jerked upward through the concentrated fishes, hooking them at random by their bellies, fins, snouts, or tails.[1]

Trachurus murphyi Nichols. "Jurel." One, North Chincha Island, October 13, 1919; one, Central Chincha Island, October 27, 1919.

Trachinotus paloma Jordan and Starks. "Pámpano." Lobos de Tierra Island, January 10, 1920. Young ("pámpanitos") seined in shallow cove, Lobos de Tierra Island, January 6, 1920.

Acanthistius pictus (Tschudi). "Cherlo." Several caught from dock at Pacasmayo, January 3, 1920; one specimen killed with dynamite off North Chincha Island, October 25, 1919 ("choromelo"). Two young seined in cove at Lobos de Tierra Island, January 6, 1920 ("ayanquito").

Hemilutjanus macrophthalmos (Tschudi). "Ojo de Uva." Three specimens killed with dynamite off North Chincha Island, October 25, 1919.

Paralabrax humeralis (Cuvier and Valenciennes). "Cabrilla," "Cabrilla fina." Specimens from Lobos de Tierra Island, South Guañape Island, Isla Blanca Pisco Bay, Pescadores Island off Ancon, North Chincha Island.

Paranthias furcifer (Cuvier and Valenciennes). "Cabinsa." South Guañape Island, January 1, 1920. This fish shares with *Isacia* the name "Cabinsa" on account of superficial resemblance.

Neomænis peru, new species

Type, No. 7415, American Museum of Natural History, Lobos de Tierra Island, January 6, 1920, R. C. Murphy; our only specimen. Length to base of caudal, 280 mm. Depth in this measure, 2.9; head, 2.6. Greatest thickness in head, 2.2; eye, 4.5; snout, 3.0; interorbital, 4.0; maxillary, 2.9; longest dorsal spine, 2.9; second anal spine, 4.5; longest dorsal ray, 3.7; longest anal ray, 2.1; pectoral, 1.3; ventral, 1.8; caudal (to tip of upper lobe), 1.4½; depth of caudal peduncle, 3.3.

Back little elevated. Lower jaw slightly projecting, maxillary not quite reaching front of the large eye. Teeth in jaws small, upper jaw with small weak canines, none in the lower jaw. Villiform teeth on vomer, palatines and tongue, those on the vomer in a roughly diamond-shaped patch somewhat prolonged behind so that the two posterior faces of the diamond are concave. Preopercle finely serrate behind, more coarsely so on its lower limb. Posterior margin with a very shallow re-entrance. Interorbital strongly convex. Ten gill-rakers on the lower limb of the first arch, the longest ½ eye. Dorsal X, 13. Anal III, 8, pointed, the second spine a little shorter but stronger than the third. Caudal lunate, with pointed lobes, the upper a little the longer. Scales below the lateral line roughly parallel with it, those above in very oblique series, about 56 in number. Scales on cheek and opercle but none on preopercle. Head naked

[1]Murphy, *loc. cit.*, p. 52.

above. A single row of large scales with several rows of smaller ones behind it slanting across the side of the nape, and an area with small imbedded scales behind eye.

Color in spirits pale brownish, darker above, a dusky spot in the axil, central caudal rays narrowly tipped with black. Color in life red, the fish resembling *Holocentrus* in color and general appearance.

The species is evidently a food fish of considerable importance, for the Indians from whom the specimen was obtained at Lobos de Tierra had already salted several hundred of the same kind. Its vernacular name is "estrella."

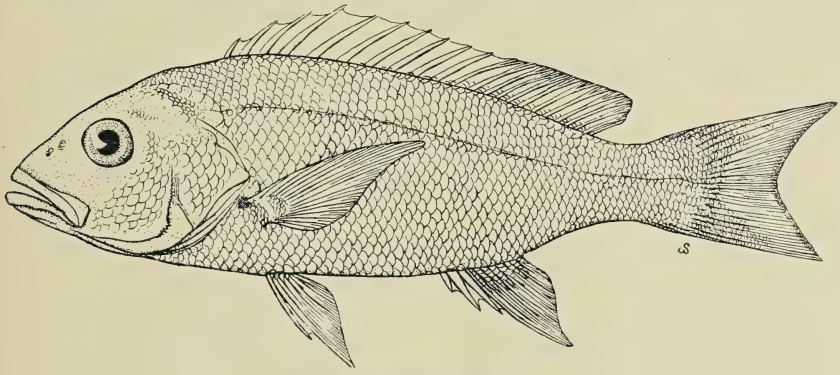

Fig. 1. *Neomænis peru*, type.

Xenistius californiensis Steindachner. "Jurelcito," "Chulita," "Cabrillita," "Chitita," names probably given erroneously under the impression that this is the young of familiar species. Several hundred specimens seined off sandy beach, North Chincha Island, November 23 and 24, 1919. About fifty specimens, cove on Lobos de Tierra Island, January 6, 1920. All young.

Anisotremus scapularis (Tschudi). "Chita." A few, North Chincha Island, etc., and one Callao market, December, 1919.

Isacia conceptionis (Cuvier and Valenciennes). "Cabinsa." Chincha Islands, early November, 1919 (3 specimens), and Pescadores Islands, off Ancon, December 13, 1919.

Doydixodon lævifrons (Tschudi). Called "chititas," and considered to be the young of *Anisotremus scapularis*. A number from rock pools, South Chincha Island, November 21, 1919. The large specimen figured ("babunco") Pl. XXVI, was taken at the Ballestas Islands, on November 30.

Cynoscion analis (Jenyns). "Robalito." Three specimens, Callao market, December, 1919.

Stellifer minor (Tschudi). "Mojarilla." Three specimens from dock at Pacasmayo, January 3, 1920, etc. On the long pier at Pacasmayo, January 8, there were many fishermen catching this sand haunting fish with "sand-bugs" (*Emerita analoga*) for bait.

Sciæna fasciata (Tschudi). "Burro," "Caracha," "Pintadilla." Several specimens; Chincha Islands, Paracas Bay, Pacasmayo.

It seems to us peculiarly unfortunate that this fish is set off by Evermann and Radcliffe from its congeners by lesser scale count. The scales of our specimens are sufficiently irregular in arrangement to allow of considerable latitude in counting, but appear smaller than those of *Sciæna gilberti!*

Sciæna deliciosa (Tschudi). "Ayanque," "Lorna." Two specimens, seined in cove at Lobos de Tierra Island, January 6, 1920, ("Ayanquito"); one seined off beach of North Chincha Island, November 24, 1919; larger ones from Callao market, December 18, 1919. One caught in casting net, Paracas Bay, November 11, 1919. The specimen last mentioned is deeper and more compressed than the others of the same size, with different outlines, but we find no technical characters to separate it.

Sciæna gilberti Abbott. "Corvina." Young examples called "Corvinita" and "Lorna." One, 24 inches long, Callao waterfront market, December 24, 1919. We also place here a small fish, obtained with *Sciæna deliciosa* of same size, Callao market, December 18.

Menticirrhus cokeri Evermann and Radcliffe. Two specimens, one seined off sandy beach, North Chincha Island, November 23 and 24, 1919.

Polyclemus peruanus (Steindachner). "Coco." Callao waterfront market, December 24, 1919.

Oplegnathus insignis (Kner). "Castañeta," "Señora"; "Mero" (the large black examples). Specimens from North, South and Central Chincha Islands.

This fish reaches a size of at least 28 inches total length. One of approximately this size was killed by dynamite, in about 5 fathoms of water over rocky bottom. Another of 14 inches killed at the same time was preserved. These large specimens were uniform blackish in life. Smaller ones marked with yellow and black bands were common in rock pools at the Chincha Islands.

Caulolatilus princeps (Jenyns). "Pejeblanco." Specimens from Chincha and Pescadores Islands; and one from South Island of Guañape, January 1, 1920, caught on hand line in rock pool. The depth as given by Evermann and Radcliffe does not hold for this material. Specimens 200 to 360 mm. long to base caudal have depth, 3.4 to 3.7; head, 3.5 to 3.6. Dorsal soft rays, 26, anal 25.

Pinguipes chilensis (Molina). "Camote." Killed with dynamite, North Chincha Island, October 25, 1919.

Cheilodactylus variegatus Cuvier and Valenciennes. "Pintadilla." Specimens killed with dynamite, North Chincha Island, October 25, 1919; and one, South Island of Guañape, January 1, 1920, caught on hand line in rock pools.

Chromis crusma (Cuvier and Valenciennes). "Coco" (at the Chincha Islands). Coker gives "Chavelita" and other names. Four specimens dynamited, North Chincha Island, October 25, 1919.

Nexilosus latifrons (Tschudi). "Coco," "Coquito." Rock pool in cave, South Chincha Island, November 21, 1919.

Bodianus eclancheri (Valenciennes). "Negro." Lobos de Afuera Island, January 5, 1920.

Pimelometopon darwinii (Jenyns). "Mulata." Three specimens dynamited, North Chincha Island, October 25, 1919; and one from Lobos de Tierra Island, January 13, 1920.

Halichœres dispilus (Guenther). "Doncella," (Central and Southern); "San Pedrano," (Northern). Specimens from North Chincha and Lobos de Afuera Islands.

Balistes polylepis Steindachner. "Cochino," "Pejechancho." Lobos de Tierra Island, January 8, 1920.

Spheroides lobatus (Steindachner). "Póncoñol." Caught on hook, Lobos de Tierra Island, January 8, 1920.

Sebastodes chincha, new species

Eight specimens of Scorpænidæ from the Chincha Islands varying from 35 to 95 mm. in length, collected in November, 1919, are referable to a single species. The vernacular name is "Peje-Diablo." They agree with *Sebastodes* (*Sebastichthys* is used by Evermann and Radcliffe) and suggest *S. rosaceous* of the North American coast, except that, whereas teeth are well developed on the vomer, they appear to be absent from the palatines. Although this character would technically throw them into *Sebastopsis*, they are here described as *Sebastodes* on the basis of their apparently close relationship to species of that genus. Eleven soft dorsal rays only, and invariably, exclude the possibility of their being *Sebastichthys chamaco* Evermann and Radcliffe, which has 14, though they look very much like the figure of that fish.

Characters of the Species.—Dorsal XII, I, 11; Anal III, 5½. Scales firm, ctenoid. Head scaly except for jaws which are naked. The two upper rays of pectoral simple, then 5 branched rays, eleven lower rays, including the excerted ones at

apex of the fin, simple. Interorbital narrow and concave. Gill-rakers short and stumpy. Second anal spine longer and stronger than third. Three or four sharp spines on the mid-line of the caudal peduncle above. Bright red in life. Brownish with dark saddles in spirits. Peritoneum pale.

Description of Type.—No. 7784, American Museum of Natural History, Chincha Islands, November 23 to 30, 1919, R. C. Murphy. Length to base of caudal, 95 mm. Depth, 2.7 in this measure; head, 2.6; greatest thickness (back of head), 4.1. Eye, snout, and depth of peduncle equal, 3.7 in head; interorbital, 6.2; maxillary, 1.7; longest dorsal spine, 2.8; second anal spine, 1.8½; longest dorsal ray, 2.3; anal ray, 2.1; pectorals, 1.2; ventrals, 1.6; caudal (equals maxillary), 1.7. The

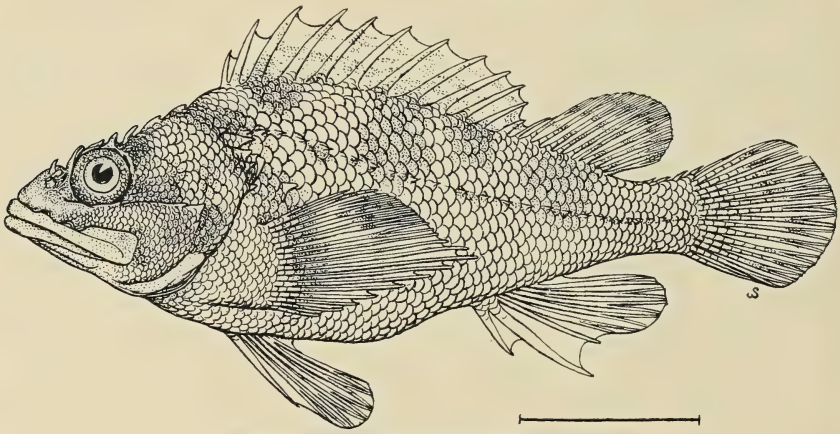

Fig. 2. *Sebastodes chincha*, type, scale 1 inch.

upper edge of pectoral consists of two approximate slender rays or one deeply divided ray. Below this are 5 well-forked rays, and then several thick, simple, more or less excerted ones. Back elevated; jaws equal. Developed gill-rakers, 2 plus 5. A short, sharp nasal spine. A low, blunt preocular spine. Supraocular, postocular, tympanic, parietal and nuchal spines present. The postocular larger than the supraocular, the tympanics farthest apart; parietal and nuchal close together forming a ridge diverging caudad from its fellow. A sharp suborbital ridge with its largest spine under the posterior part of the eye. A very small spine further forward, and a small one at its posterior terminus in front of the upper preopercular spine. Three spines on the preopercle, the upper slightly the largest. Two on the opercle of about equal size. Two small ones, one before the other, at the shoulder, and one over the pectoral. Coronal spine very small, sharp. A pair of low ridges in the interorbital space, each ending in a low spine. Four sharp spines on the mid-line of the caudal peduncle above, the next to the last best developed. About 45 scales.

Scorpæna histrio Jenyns. "Peje-Diablo." Specimens from South Guañape Island.

Paralichthys adspersus (Steindachner). "Lenguado." Specimens from sandy beach, North Chincha Island; seined at head of Independen-

cia Bay; Central Chincha Island, October 26, 1919, (bright green eye surrounded by gold line); and Callao market.

Lepisoma xanti (Gill). "Trambollo." Specimens from South Guañape Island, and South Chincha Island.

Alticus gigas (Steindachner). "Borracho," "Sueño." Windward rocky beach, South Chincha Island, November 22, 1919. "Borracho" means drunk, and eating this fish is supposed to make one sleepy and to cause dreams. A meal of them acts like a heavy dose of a narcotic, according to Indians at the Chincha Islands.

Salarias rubropunctatus Cuvier and Valenciennes. "Borrachin." Eleven specimens seined off beach of North Chincha Island, November 24, 1919.

Genypterus chilensis (Guichenot). "Congrio." Dynamited, North Chincha Island, October 25, 1919.

Gobiesox sanguineus (Mueller and Troschel). "Pejesapo." Several from the Chincha Islands.

Arbaciosa hieroglyphica Evermann and Radcliffe. "Pejesapo." One from lagoon of Paracas Bay, November 12, 1919. Two young specimens seined in cove at Lobos de Afuera Island, January 5, 1920.

A DISCUSSION OF THE PERUVIAN SHORE FISHES

The entire Peruvian coast lies well within the tropics. Nevertheless, its shore-fish fauna is subtropical or temperate rather than tropical in character. The reason is not far to seek, namely the cold Humboldt Current. As a matter of fact, Peruvian fishes are somewhat comparable with those of the Mediterranean. We find here an admixture of species which are more abundant near the Equator with others which are distinctly temperate, such as *Trachurus*.

The closest faunal affinities are with the Californias, many species being common both to the coast of Peru and to the waters lying just outside the tropics in the northern hemisphere. The present collection has increased the number of forms common to the temperate waters of the two hemispheres. The two new species described are related to California species, and six of the other eight added to the fauna of Peru are California species. Only two of the additions are widely distributed tropical forms.

It is interesting to contrast these conditions as existing in the Pacific with conditions on the Atlantic coast of the Americas. In the Atlantic there are two sharply marked faunæ, the Boreal and the Equatorial; Cape Cod in summer and Cape Hatteras in winter divide them. The

northern fauna extends little changed from this point to the shores of Greenland, the southern as little changed across the Equator to Rio de Janeiro, Brazil, at the Tropic of Capricorn. The reason is obvious. Here the Trade Wind currents, deflected by the continents to leeward, spread out fanwise, over many degrees of latitude, giving the whole area a very similar warm-water fauna.

In the Pacific conditions are reversed. Currents flow from high latitudes towards the Equator. This restricts the tropical area to a very narrow belt, so narrow, indeed, that it is crossed by a number of species; though sufficiently effective to divide the fishes of California and Mexico from those of Peru to a greater extent than those of Florida are separated from South Atlantic Brazil.

As we go northward there is no such sharp line in the North Pacific as we find between warm and cold-water fishes in the North Atlantic. This would reasonably be the case because the higher latitudes of the west coast of America are to leeward of the ocean and therefore have a more equable temperature. Perhaps the isolation of the Pacific from the Arctic by Bering Strait and the shallow sea between it and the Aleutians is also a contributing factor.

One can scarcely consider the peculiar and unfamiliar relationships of the Peruvian fish fauna—a temperate fish fauna in the tropics of the southern hemisphere allied to the temperate fish fauna of the northern hemisphere—without becoming interested in primary divisions of the world's fish faunæ.

The fishes of the world lend themselves most conveniently to primary faunal divisions not by climates or continental isolation, as is the case with every other class of vertebrates, but by conditions of waters in which they occur. Beginning at the bottom are the deep-sea fishes found for the most part below the 100-fathom line. Secondly, we have the shore fishes occurring on comparatively shallow off-shore banks as well as along the coast-line. Fishes of the high seas, occurring at the very surface of the ocean, even in parts most remote from land, do not form a group by themselves, but merely a sub-division of the tropical sub-division of shore-fishes.

Another primary group would be fresh-water fishes of all the continents and the larger islands. We have drawn up below a provisional schedule of primary divisions and sub-divisions of the world's fish fauna, arranged in key form, based on such data as are immediately at hand, adding in parentheses characteristic forms of some of the divisions, and general boundaries of the marine shore divisions.

FAUNAL DIVISION OF THE FISHES OF THE WORLD

1.—(*a*) Fresh-water fishes; see 2.
(*b*) Marine fishes; see 3.
2.—(*a*) Holarctic (Cyprinidæ); see 4.
(*b*) Southern (Cichlids and Characins); see 5.
3.—(*a*) Deep-sea fishes (below 50 fathoms, and sub-surface on the high seas).
(*b*) Shore fishes (down to 100 fathoms, and surface of the high seas); see 7.
4.—(*a*) Arctic (*Salvelinus*).
(*b*) Asiatic (*Cobitis*).
(*c*) North American (Centrarchids).
5.—(*a*) African (Mormyrids).
(*b*) Neotropical; see 6.
(*c*) Australian (Primitive fishes only).
6.—(*a*) Central American (Viviparous Pœcilliids dominant).
(*b*) South American (Gymnotids).
7.—(*a*) Boreal (Cottids and Gadids. Roughly extending southward to Alaska, Boston, Mass., Norway, and the sea of Okhotsk).
(b^1) Pacific Temperate (*Sebastodes*); see 8. (Roughly meeting the Arctic fauna in northern Japan; along the A eutians and south to Mexico, more or less broken at the Equator to appear again on the coast of Peru).
(c^1). Mediterranean. (Roughly from British Isles to Mediterranean).
(d^1) Cape Temperate. (Roughly, Cape of Good Hope, S. Australia, New Zealand, etc.).
(*e*) Tropical; see 9. (Roughly warm seas of the World, the complement of 7 *a*, *b*, *c*, *d*, *f*).
(*f*) Southern (Nototheniids. Roughly Antarctic and Subantarctic seas, north to the limit of Nototheniids).
8.—(*a*) Northern.
(*b*) Peruvian.
9.—(*a*) Shore (Scarids and Pomacentrids); see 10.
(*b*) High seas (*Coryphæna* and Exocœtids).
10.—(*a*) Pacific.
(*b*) Indian.
(*c*) Atlantic.

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[1] *Trachurus*, characteristic of three temperate divisions.

Limiting the discussion to shore fishes which make up very much the majority in species and individuals of the fish life of the world, they are divided, much as are the faunal groups of land animals, by the joint control of two factors, climate and isolation. Lines of phylogenetic relationship tend to develop within the limits of a single group but also run across the groups, and in so doing give what would seem to be an indication of the relationship of group to group and of the evolution of the faunæ as we now find them.

The Arctic or Boreal fauna shows closest phylogenetic affinities with the temperate Pacific fauna. An incident of this is to be found in the abundance of cottoid fishes. Comparing the Arctic with the temperate Pacific cottoids, it will be noticed that it is among the latter that the more primitive forms are extensively developed. According to Matthew's Law of Dispersal the primitive forms should continue to exist at the periphery of an evolutionary center. If we accept this view we have an Arctic influence predominating among temperate Pacific fishes, and crossing the Equator to Peru.

Again, the affinities of the Mediterranean or Atlantic temperate fauna are with the tropical. An incident in this relationship is the development of the wrasses in each. The temperate wrasses are obviously more primitive than those of the tropical coral reefs, and by Matthew's Law again the tropics are near the center of distribution and the tropical influence extends northward to the British Isles.

The influence of the third, the southern or Antarctic element, appears to be confined more or less within its own boundaries.

PLATES XXV AND XXVI

PLATE XXV

(Figures 1 and 2)

Germo argentivittatus (Cuvier and Valenciennes). Caught on hand line between Lobos de Afuera and Lobos de Tierra Islands, Peru, January 5, 1920.

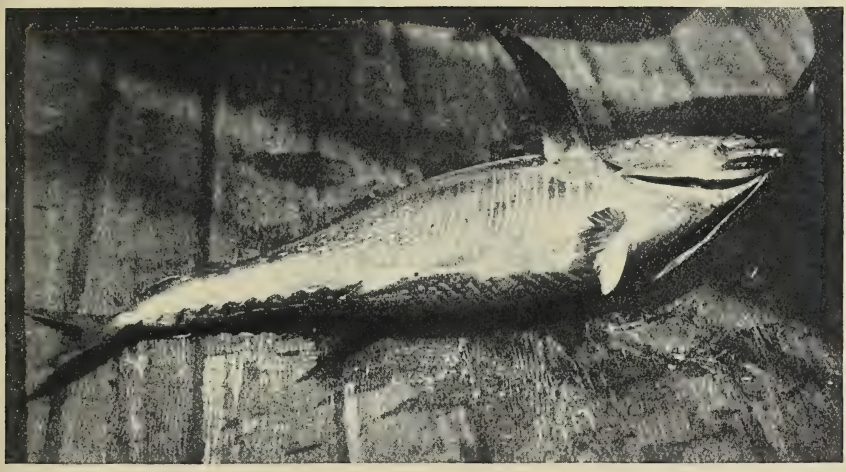

Plate XXVI

Fish from rocky bottom, Ballestas Islands, Pisco Bay, November 30, 1919.

Fig. 1. Left to right: mulata (*Pimelometopon darwinii*); babunco (*Doydixodon lævifrons*); cabrilla (*Paralabrax humeralis*); cabrilla (*Paralabrax humeralis*); ojo de uva (*Hemilutjanus macrophthalmos*); burro (*Sciæna fasciata*); coco, chavelita (*Chromis crusma*); chita (*Anisotremus scapularis*).

Fig. 2. Left to right: mero, señora (*Oplegnathus insignis*); pintadilla (*Cheilodactylus variegatus*); mulata (*Pimelometopon darwinii*).

59.14.98,1:81

Article X.—THE LOCOMOTOR APPARATUS OF CERTAIN PRIMITIVE AND MAMMAL-LIKE REPTILES[1]

By Alfred S. Romer

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[1]Studies in Comparative Myology and Osteology from the Laboratory of Comparative Anatomy, No. VI.

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INTRODUCTION

The locomotor apparatus of the primitive Permo-Carboniferous reptiles of the Texas deposits, and of the mammal-like forms of the South African Permian, has been of interest since the first discovery of these groups in the middle of the last century. The accumulation of evidence shows that the cotylosaurs and pelycosaurs are in their limb structure close to the typical Stegocephalia and through them not far removed from the primitive tetrapod type; while, on the other hand, the ancestors of all the amniotes are to be sought among them. Hence their limbs, although radically different from those of any existing forms, are close to the common type from which those of higher sauropsids and mammals have arisen. The mammal-like forms, or therapsids, bridge much of the gap between primitive reptiles and mammals. These two groups thus have an important bearing on the study of the tetrapod limb.

Unfortunately, most workers on these forms have been intent on skull structure and few comparative studies have been made of the limbs. Recently, however, Watson (1917*a*) has discussed many of the questions involving the fore limb and Gregory and Camp (1918) have discussed the general homologies of tetrapod limb muscles and restored the musculature of some South African forms. The present paper is an attempt at a further analysis of the locomotor apparatus of certain cotylosaurs, pelycosaurs, and therapsids, with reference to the musculature, bony structure, and movements of the girdles and limbs. Comparisons have been made with the Stegocephalia, some of which are exceedingly close in their structure, and certain points which seem of interest in connection with the first stages in the evolution of the tetrapod limb have been considered.

In the restoration of the musculature, the immature state of comparative myology has been a great handicap. This is reflected in the texts on comparative anatomy, which under musculature usually speak briefly of a few general topics, as flexors and extensors, and then pass quickly on to firmer ground. Numerous excellent papers on special forms or muscle groups have appeared, those of Fürbringer (1873, 1874, 1876, 1900) on the shoulder and Gadow (1882) and Perrin (1892, 1895) on the posterior extremity being especially noteworthy; but few have attempted any broad comparisons between groups. Consequently, I have found it necessary in great measure to make anew an analysis of the relations of the muscle groups of the living types in order to interpret the indications of muscular origins and insertions found on the fossil skeletons. A discussion of the various groups of limb muscles has been in-

cluded in the hope that this would be of benefit to comparative myology, especially so because here it is unnecessary to appeal to imaginary "Archetypes" since the forms under discussion are exceedingly close to the actual connecting links.

An attempt at a complete restoration of these extinct types allows much opportunity for error. Even if sure of the origin and insertion of a muscle, its exact size may be uncertain. The definite boundaries of a fleshy origin are difficult to delimit. Often, as in the case of the latissimus dorsi, one end of a muscle may be determined with much certainty but the other extremity may be beyond our power to locate exactly. The poor character of the surface of the fossil bones, especially of those types the material of which is scant, leaves doubt as to the details of the muscles connected with them. This is especially true of the South African forms, where the matrix is usually very difficult. But in spite of this, it has been thought best to present a completed picture in order to provide a basis for further work.

Under both fore and hind limb, the probable musculature of *Diadectes* (a primitive cotylosaur), *Dimetrodon* (an advanced pelycosaur), and *Moschops* (one of the lowest therapsids) has been restored, with a discussion of the distribution of the muscles involved in various modern and extinct forms. For comparison, views are given of the muscles of *Iguana* and *Didelphys*, as fairly representative of living reptiles and mammals. Then follows a general dicussion of the bones in relation to locomotion in the fossil groups as a whole. Brief summaries are given of the various types of locomotion discussed and some of the points on the relationships of the various groups, as suggested by the limbs, are noted. Finally, a table of homologies of limb muscles in urodeles, reptiles, and mammals is presented.

For uniformity, all views are of limbs and bones of the right side. Because of breaks, crushing, erosion, and immaturity of the specimens at death, it is seldom that any one fossil bone will give a complete picture. Consequently, the illustrations are almost without exception composites, based upon a study of most of the American material and of the Broom collection from South Africa in The American Museum of Natural History.

It is impossible to give in a brief space the complete synonymy of muscle terminology. In each instance the most commonly used names of the muscle or muscles involved are given; if the mammalian terms differ from the reptilian, the latter are given first, the former added in parentheses.

The criteria for muscular homologies have been often discussed. Function, it is agreed, is of little value. Homology of origin and insertion are of great value. The relative position of adjacent muscles is of importance.

The question of innervations is most often debated. That there is a relation of some sort between muscle masses and nerves, a thesis especially

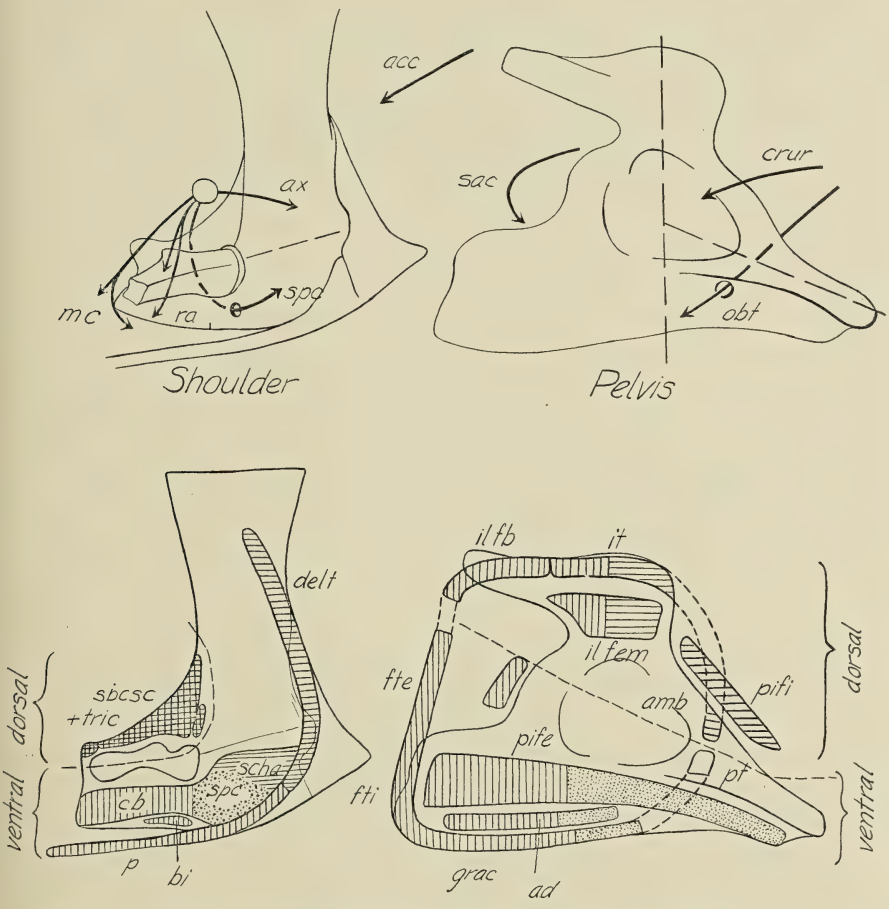

Figure 1. Diagrams to show the primitive areas of innervation of pectoral and pelvic girdles (above) and the distribution of the proximal portions of the primitive dorsal and ventral muscle masses (below). In the pectoral girdle the dorsal muscle mass is innervated by short branches from the plexus and radial nerves (*Ra*) (cross-hatching). The ventral mass is innervated by the "axillary" nerves (*Ax*) (horizontal ruling), the supracoracoid or suprascapular (*Spc*) (stippled), and by them usculo-cutaneous (*Mc*), median and ulnar nerves (vertical hatching). The accessory (*Acc*) nerve innervates all or part of the primitive trapezius group. In the pelvis the posterior portion of both dorsal and ventral masses is innervated through the sacral plexus (*Sac*) (vertical ruling). The anterior end of the dorsal mass is innervated by the femoral or other nerves of the lumbar plexus (*Crur*) (horizontal ruling); the anterior end of the ventral mass by the obturator nerve (*Obt*) (stippled).

upheld by the Heidelburg school, cannot be doubted; many peculiarities in innervations are explained by reference to their phylogenetic history; the peculiar distribution of the saphenous nerve in the monotremes, as discussed by Ruge (1878, p. 599), Westling (1889, p. 54), and Frets (1910, pp. 20, 21), is the only flat contradiction to this assumption and even this may prove to have an explanation, while some of the recent experimental work (as Detweiler, 1920) seems to show that similar relations exist in ontogeny.

Great difficulty is caused by our inability to be sure of the homology of the nerves themselves in two different animals. A homology of the finer branches, such as that attempted by De Man (1873) in the Amphibia, has proved valueless. Many general topographic divisions, such as Fürbringer's into dorsal and ventral rami, are also of little value in this connection. It is obvious that, if a muscle is ventral in position, the nerve innervating it will of necessity be a "ventral ramus," and vice versa; and he himself (1876, p. 719) admits that the distinction breaks down in the case of the suprascapular (supracoracoid) nerve, where the muscular homologies are fairly obvious. Neither will the course of a nerve in relation to the adjacent muscles prove its identity, as is witnessed by the tibial nerve of salamanders, which Siegelbaur (1904, p. 390) has shown may pass to either side of the femoro-tibialis or through it. It is usually impracticable to trace the fibers through the plexus and ascertain their segmental origins; and, with our present lack of knowledge of segmental values, the usefulness of this would be questionable.

On the other hand, the relation of the nerves to the bones of the limbs and girdles seems fairly constant and gives us at least some major topographical divisions upon which we may rely with fair certainty. (Fig. 1.) In the fore limb (Fürbringer, 1873, etc.), the distribution of the supracoracoid (suprascapular) nerve (*Spc*) seems to be distinct from that of the nerves which pass from the axillary region either antero-dorsally (axillary or radial nerve or equivalents, *Ax*, *Ra*) or postero-ventrally (musculo-cutaneous or equivalents, *M–C*); while the distinctive vagal innervation of the trapezius and its derivatives offers another point of attack. In the hind limb, three regions, recognized by Gadow (1882), may be distinguished: (1) that of the lumbar plexus and femoral nerve, anterior to the ilium (*Crur*); (2) that of the obturator nerve (*Obt*); and (3) that of the nerves of the sacral plexus emerging posterior to the ilium (*Sac*).

The question of double innervations is of great importance in the study of musculature. Cases of this occur in most of the muscle groups

of the upper leg and in the muscles running to the humerus. Some have tended to look upon these cases as examples of a secondary fusion of primitively separate muscles, but their constant reappearance in similar muscles in widely separated forms tends to discredit this view. Even on *a priori* grounds there is no reason to believe in the "purity" of innervations, since unquestionably the limb musculature is derived from a primitively segmental musculature. Frets (1910, p. 91) suggested that this might be the case in those instances which occur in the Monotreme; these double innervations will be discussed further on in connection with the muscular groups concerned.

The following is an outline of the general systematic position of the fossil forms discussed. Fuller classifications of these groups have been made recently by Watson (1917) and Williston (1916 and 1917).

Class AMPHIBIA

Subclass STEGOCEPHALIA.—Including all primitive forms of the class; all extinct

Order Temnospondyli

Suborder Embolomeri.—Considered (especially by Watson, 1919, etc.) as the most primitive tetrapod group. *Cricotus*

Suborder Rachitomi.—More "advanced" forms. *Eryops, Cacops, Achelomma, Cochleosaurus*

Order Lepospondyli.—"Microsaurs," etc. Possibly a composite group; although most of its members are very specialized, their relationship to primitive reptiles has been suggested. *Diplocaulus, Ichthyacanthus, Batrachiderpeton, Keraterpeton*

Class REPTILIA

Series ANAPSIDA

Order Cotylosauria.—"Stem reptiles," with roofed skulls. As to limb structure they may be divided as follows

(*a*) Forms with primitive limbs. (American) *Seymouria, Diadectes, Diasparactus, Limnoscelis.* Although these forms differ greatly in other respects, the limbs are essentially the same

(*b*) More advanced American types. Captorhinomorpha of Watson in part, *Captorhinus, Labidosaurus, Pariotichus, Pleuristion*

(*c*) Of uncertain position. *Archeria,* known only from the humerus

(*d*) Pareiasauria. Old world Permian forms with a combination of primitive, specialized, and mammal-like characters, the latter usually considered as specializations. *Pareiasaurus, Propappus*

Series SYNAPSIDA

Order Pelycosauria or Theromorpha.—An assemblage of great diversity, possessing a lateral temporal opening and usually other advanced characters over the last-named order.

Family Caseidæ. *Casea*
Family Poliosauridæ. *Varanosaurus, Varanoops, Pœcilospondylus*
Family Ophiacodontidæ. *Ophiacodon, Theropleura*
Family Clepsydropidæ. *Dimetrodon, Clepsydrops*
Family Edaphosauridæ. *Naosaurus, Edaphosaurus*
Forms of uncertain position. *Aræoscelis* and *Kadaliosaurus*. Considered by Williston to be ancestral to lizards

Order Therapsida.—Mammal-like reptiles, chiefly South African.

Suborder Dinocephalia.—The most primitive therapsid group adequately known. *Moschops*

Suborder Dicynodontia.—Advanced therapsids, but specialized in dentition, etc. *Dicynodon*

Suborders Gorgonopsia, Therocephalia, Bauriamorpha, Cynodontia (Theriodontia) —A series of groups more generalized in character and with stages leading toward. the mammalian type of organization. *Cynognathus, Ictidosuchus*

I wish to acknowledge my debt of gratitude to Dr. W. K. Gregory, of Columbia University and The American Museum of Natural History, at whose suggestion and under whose direction this work was undertaken. I have benefited greatly from discussion with my fellow students in myology, C. L. Camp, J. P. Chapin, and G. K. Noble.

I am greatly indebted to the authorities of The American Museum of Natural History, and especially to Dr. W. D. Matthew, Curator of Vertebrate Palæontology, for allowing me free use of their abundant material, as well as giving me every working facility. To the New York Academy of Sciences I am indebted for a grant which has enabled me to visit the other principal American Permian collections. I owe my thanks to Dr. E. C. Case of the University of Michigan, Dr. T. C. Chamberlin and Mr. Paul C. Miller of the University of Chicago, Dr. R. S. Lull of Yale University, and Dr. C. W. Gilmore of the National Museum of Washington, for allowing me the opportunity of studying the many interesting forms to be found in the collections in their charge.

After the completion of this paper, I had the pleasure of discussing the shoulder musculature with Mr. R. W. Miner, who is engaged in the restoration of that region in *Eryops*, and found that we were in substantial agreement as to many of the determinations involved.

FORE LIMB, MUSCULATURE

1.—Trapezius (and Sterno-cleido-mastoideus)

Plates XXVII, dotted outlines; XXXIII, insertions

Superficial; usually the only muscle of the shoulder belonging to the visceral arch series, as shown by its whole or partial innervation by the vago-accessorius nerve. Its history is obscured by the fact that its in-

sertion leaves little impression on the bone. Further, its history is bound up with that of the dermal girdle and we have no living tetrapod in which this is complete. In the elasmobranchs, the muscle originates from the back fascia and runs diagonally down and back to the anterior border of the scapulo-coracoid. In higher forms its anterior portion attains the skull, a connection retained by at least some part of the mass in most tetrapods. The more ventral and anterior part tends to be split off in higher forms as a sterno-cleido-mastoideus or its equivalent.

The presence of the dermal girdle has affected the muscle in three ways: (1) the connection between girdle and skull has resulted in a reduction of the muscle in some forms, as the sturgeon, and its absence in teleosts (the "trapezius" of that group belonging to another system, Vetter, 1876, p. 526); (2) the series of bones from the head to the girdle may result in the separation of localized slips, as the one running from supracleithrum to the scapula in *Acipenser* (Meissner, 1908, p. 466); and (3) the insertion may be taken over by the dermal girdle. The latter is partly the case in the sturgeon (Meissner, 1908, p. 466) and *Polypterus* (Shann, 1920, fig. 24), and the conditions in Stegocephalia and cotylosaurs force us to the conclusion that this has also happened in the tetrapod stem.

The ventral portion (sterno-cleido-mastoid) usually inserts on the dermal girdle when clavicles (and interclavicle) are present. The trapezius proper either inserts into the "acromial region" (urodeles, lizards, *Sphenodon*, crocodiles) or the mammalian scapular spine, thus extending farther dorsally. This suggests that, with the loss of connection between dermal girdle and head, a backward extension of the muscle took place; that it then inserted along the whole length of the subsequent "capping" cleithrum of *Eryops*, *Diadectes*, etc; and that with the reduction of this element the muscle insertion either followed the dwindling bone down to the "acromial" region in reptiles or was transferred *in situ* to the scapula in the mammalian line (to the spine or its earlier homologue, the anterior edge of the primitive scapula).

2.—Axial Muscles Acting on the Girdle

Plates XXVII, XXVIII; XXXIII, XXXIV, insertions

a.—Dorsal: *Levator Scapulæ* (and *Atlanto-scapularis*, *Atlanto-acromialis* or *Omo-trachelius* and *Rhomboideus*), *Serratus Anterior*. These variously named muscles are apparently antero-posterior differentiations out of a series arising from the lateral axial muscles. Their origins take a general course from the skull back and down along the tips of the ribs (or

transverse processes if cervical ribs are absent) to a termination posterior to the scapula. They insert mainly on the dorsal portion of the inner surface of the scapular blade. The most anterior and posterior members of the series are usually better differentiated.

The former, as a levator scapulæ, is found in many reptiles inserting on the anterior edge or the outer surface of scapula and clavicle. This suggests that it attached to the cleithrum in primitive forms and that the history of its insertion has been similar to that of the trapezius. (Miner makes the interesting suggestion that it may be related to that muscle.) The monotreme omo-trachelius is similar. The development of the supraspinous fossa in higher mammals has apparently caused a break in the muscle, part (as in *Didelphys*) moving dorsally with the supraspinatus as an atlanto-scapularis or omo-trachelius dorsalis, part often remaining ventrally as a levator scapulæ ventralis, atlanto-acromialis, or omo-trachelius ventralis, as suggested by Gregory and Camp (1918, p. 466).

The posterior muscle, serratus anterior superficialis, has a well-marked point of attachment to the upper part of the posterior edge of the scapula in most Permian forms, comparable to that in modern reptiles. This condition is also indicated in *Cynognathus* by Gregory and Camp (in the figures, Pl. XL, teres major and serratus superficialis are accidentally reversed). It was probably later than this, and connected with the development of teres major, that the muscle disappeared in the mammalian line.

The median group (deep levators, serratus anterior) is remarkably uniform throughout, their insertions occupying a small area near the top of the scapula. The origins (marked in a number of extinct forms by uncinate processes much as in some lizards) are from the transverse processes and ends of the ribs. The number of slips increases greatly in mammals.

b.—VENTRAL: *Sterno-*(*episterno*) *hyoideus* and *omo-hyoideus*; *Sterno-costo-coracoidei* (*Subclavius, ?Pectoralis minor*). Above urodeles, the rectus in living forms is separated from the hyoid muscles at the girdle. The continuity of the two in the urodeles is probably secondary, due to a loss of the dermal girdle; but in some reptiles the omo-hyoid is connected with the sterno-"clavicular" ligament (a rectus derivative).

The reptiles show in general a thin sheet of muscle running from clavicles and interclavicle, when present, and the acromial region forward to the hyoid. There is no palæontological evidence for these slender muscles, but the similar build of the girdle indicates the same position,

the acromial portion arising from the cleithrum originally. In the mammals part has been transferred to the sternum, part has migrated dorsally, apparently in connection with the growth of the supraspinatus, as the omo-hyoid.

In all living reptiles and monotremes there is a ventral group of muscles running from the ribs and sternum and inserting into the coracoid. The hollowed-out ventral portion of the inside of the girdle in *Diadectes* and *Dimetrodon* suggests that they occupied a similar position here, more probably being part of the rectus in the probable absence of an intervening sternum. The monotreme condition is similar. It is recognized (Fürbringer, 1876, p. 711) that the subclavius is a remnant of this set (costo-coracoideus) which has survived the reduction of the coracoid plate.

The lizards and *Sphenodon* (Fürbringer, 1876, etc.) are unique in the possession of a ligament and muscle running to the scapula from this group, often connected with the coracoid head of the triceps, and passing over the ventral portion of the subcoraco-scapularis or subcoracoideus. I shall show later that the diadectids and *Dimetrodon* probably did not have a true subcoracoideus. Running across a space corresponding to the course of the modern reptilian tendon is a strong ridge of bone, pointing backward in the direction of the sterno-costo-coracoid group and probably affording an insertion for the sterno-costo-scapularis muscle. With the reduction of the posterior upper portion of the coracoid, the muscle would have been left "in the air"; apparently this has resulted in the formation of the ligament, into which the muscle now attaches instead of the bone. In *Sphenodon*, where the reduction of the coracoid has not been so extreme, the coracoid head of the triceps has kept its position; in many lizards, where the upper edge of the coracoid is too far ventrally for a coracoid head to operate from, its origin is from this ligament. Hence, it would seem that this ligament is in the main equivalent to the original upper edge of the coracoid.

No such differentiation seems to have taken place in the mammalian line; the coracoid head of the triceps has been lost, and the musculature has followed the bone in its retreat, to give the sterno- and costo-coracoidei of monotremes and their placental derivatives.

3.—Latissimus Dorsi and Teres major

Plates XXVII; XXXIII, origins; XXXV, XXXVII, insertions

The latissimus, with an origin posteriorly on the dorsal fascia and converging to an insertion which is usually near the head of the humerus, is a constant tetrapod feature. The points of interest in connection with

the muscle are: (1) the origin of the teres major; (2) the humeral insertion, in relation to the triceps heads; and (3) the dorso-epitrochlearis.

At several times the latissimus, whose anterior edge runs close to the scapular blade, seems to have acquired an insertion upon it. An equivalent of the mammalian teres major is seen in the Crocodilia and a number of lizards. There is no evidence of such an origin in the known Permian forms; considering the proximity of the latissimus to the scapula, the attachment might easily have taken place in any series. The reptilian teres major seems unquestionably a derivative of the latissimus, as shown by their common insertion, which is well distal of the subscapulo-coracoideus (the only muscle from which it might otherwise have been derived). The only therapsid indication of the muscle is that suggested in *Cynognathus* by Gregory and Camp (1918, p. 471). The placental teres, as shown by its insertion, is apparently also a latissimus derivative.

At first sight, the contrast in the insertion of the latissimus in reptiles and mammals is puzzling. In *Sphenodon* and lizards, the insertion is between the median and lateral heads of the triceps; in mammals, it is posterior to the whole triceps. But the history of the triceps heads clears up this. In *Diadectes*, the insertion of the latissimus was probably on a roughened area just external to that of the subcoraco-scapularis, between the proximal ends of medial and lateral triceps heads. In *Dimetrodon*, the insertion is shown (in six of thirty-six humeri of this type in Dr. Case's collection, for example) as a slightly roughened area farther out along the ridge separating the heads, this leading to the usual reptilian condition. But in the mammalian line, the loss of the medial mass of the triceps, to be discussed later, has left it posterior to the whole triceps.

Primitively, some of the fibers of the latissimus inserted into the medial head of the triceps; this is the usual urodele and reptilian condition. But, with the loss of the medial head of the triceps, some of this connection seems to have often been retained as a dorso-epitrochlearis, which seems to act much as a compound of latissimus and median triceps; in the monotremes, the whole latissimus seems to have adopted this course.

4.—Pectoralis

Plates XXVII; XXXIII, origins; XXXVI, insertions

The origin, primitively, seems to have been from the length of the interclavicle, the sternum when present, and the surface of the rectus. Traces of the interclavicular origin are preserved in some American Permian specimens in the grooving of the edge of the interclavicle.

Watson apparently observed the same in *Broomia* (1914, p. 998), but suggested that these grooves were shelves to receive the internal borders of the coracoids. He himself remarks that such a position of the interclavicle would be unusual.

The insertion in the fossil forms under consideration is never in doubt, a stout process ventrally from the anterior proximal portion of the humerus, the most prominent mark on the bone. This process runs proximally into a ridge at the edge of the bone into which the supracoracoideus inserts. The ridge is extremely long in the therapsids, usually about half the length of the bone.

5.—Deltoid

Plates XXVII; XXXIII, origins; XXXV, XXXVII, insertions

The deltoid group is unmistakable throughout as a series of superficial muscles running from the dorsal and anterior portions of the girdle to the proximal external (anterior) portion of the humerus. The insertion is practically stationary, being dorsal to the pectoralis, proximal to the brachialis, distal to the supracoracoideus, and external (anterior) to the scapulo-humeralis anterior.

As was the case with the trapezius, the lack of a functional cleithrum in recent forms makes its exact history somewhat less certain. But it seems probable, as Watson (1917*a*, p. 4) has suggested, that its history is closely connected with that of the dermal girdle. In primitive forms, where the clavicle and cleithrum stretched far toward the glenoid over the scapula, its dorsal reach must have been small; its dorsal expansion followed the shrinking of the cleithrum. This serves to explain the position of the deltoid throughout the series, and I have plotted the muscle on that basis. The dorsal portion still probably had a cleithral origin for the most part in diadectids, but had probably lost most or all of it in all higher forms, with the diminution or loss of the cleithrum. The same transfer to the scapula took place in the therapsids, in which a vestigial cleithrum is retained in the lower forms. It will be noted in this connection that the scapular spine is the functional representative not only of the primitive anterior border of the scapula, but of its predecessor, the cleithrum, as well.

Connections between the deltoid and trapezius and sterno-cleido-mastoideus, as into a cephalo-humeralis, are frequent. This, however, cannot have been a primitive character, as there was then a wide stretch of dermal girdle between the trapezius insertion and the deltoid origin.

6.—Subcoraco-scapularis and Scapulo-humeralis posterior (Subscapularis)

Plates XXIX, XXX; XXXIII, XXXIV, origins; XXXV-XXXVII, insertions

This group may be defined in general by its origin from the inner surface of the girdle, or posterior to the scapular head of the triceps if on the outer surface; its course between scapular and coracoid heads of the triceps when the latter is present; and its insertion on the proximal internal (posterior) angle of the humerus. This will serve to prevent confusion with the scapulo-humeralis anterior and (except in mammal-like forms) with the coraco-brachialis group below.

In *Salamandra*, the muscle originates internally, anterior to the glenoid, and takes a course to a pronounced process at the head of the humerus.

The situation in *Diadectes* and *Dimetrodon* is at first sight confusing (the cotylosaurs and pelycosaurs are similar in this region). The smooth scapular blade is bounded posteriorly by a sharp ridge, which extends upwards as the posterior border of the scapula. Behind this is found a triangular surface, perforated in many forms, by the supraglenoid foramen. Above, this surface grooves internally into the inner surface of the scapula; posteriorly, it dwindles into a narrow shelf which terminated at the coracoid triceps origin. The relative positions indicate that the scapular head of the triceps inserted on or near the anterior ridge bounding the triangular surface, and hence the subcoraco-scapularis must have inserted back of this, evidently in this triangular area. The transition to the inner surface of the scapula above leads to the inference (Watson, 1917*a*, p. 12) that the origin extended upwards here; but it is doubtful if this portion of the muscle was of much strength.

Watson (1917*a*, p. 12) suggested that there was also a subcoracoid, but any muscle running from the internal surface of the coracoid to the humerus would have to turn an angle of about 270° (Figure 2). The build of the glenoid with the ridge above it and the fact that the point of insertion cannot look down into the cavity from which the muscle arises (as it does in most reptiles) speak strongly against this view. This also agrees with the salamander condition, where the origin is anterior, and not ventral to the glenoid. The crocodile, too, has the same character of subcoraco-scapularis; there is no ventral portion.

From such a condition, peculiar as it seems at first sight, the muscle of higher forms may be easily derived. The most posterior part of the origin probably lay on the shelf above the glenoid; with the reduction of the coracoid region in lizards and *Sphenodon*, the muscle would have an

opportunity to extend down on to the coracoid, probably at first at the posterior angle. I have already discussed the possible relation of the sterno-scapular ligament to this movement.

While we have no transition from the Permian forms to the modern Reptilia, it seems probable that the triangular area, at the anterior edge of which is the scapular triceps origin, has become part of the external surface of the scapula of lizards and *Sphenodon* (where the scapular head

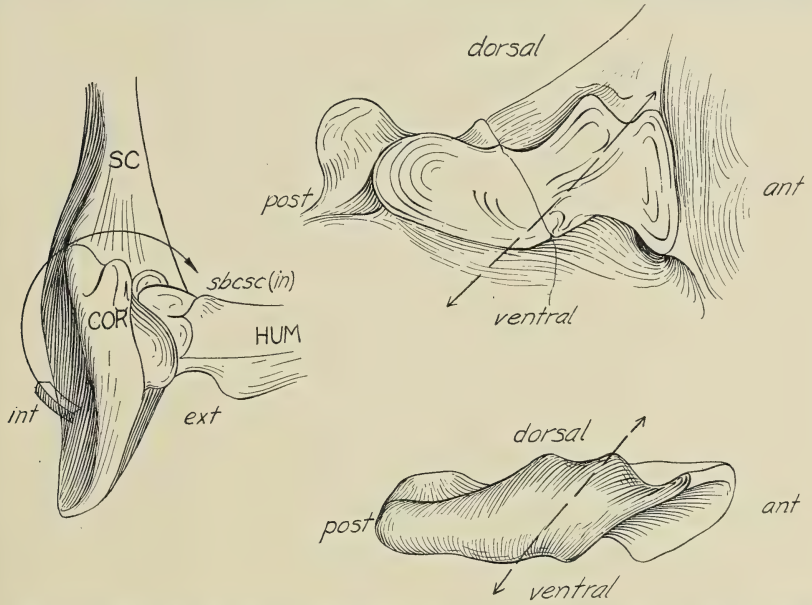

Figure 2 (left). To show the improbability of the presence of a true subcoracoideus muscle in primitive forms. The arrow indicates the course such a muscle would necessarily have taken in *Dimetrodon*.

Figure 3 (right). The right glenoid and head of the left femur of *Dimetrodon*. The broken arrows show the suggested point of division of the articular surfaces into two portions.

of the triceps is on this surface, and not at its posterior edge), and the scapulo-humeralis posterior is merely a portion of the subcoraco-scapularis mass carried outward in this process. Its course to the humerus always lies behind the scapular head of the triceps.

The evidence seems to show that the therapsids did not have a subcoracoideus homologous with that of lizards and *Sphenodon*. The monotremes have a muscle, which is similar at first sight, in the epicoraco-brachialis, the insertion of which seems to refer it to this group rather than to the coraco-brachialis (with which it is sometimes homologized, as by Westling, p. 16). But there is no formation of a sterno-scapular ligament; the entire costo-sterno-coracoideus is internal to it instead of

separating it from the subscapularis as in reptiles; and it runs more in an anterior direction than a ventral one. This all tends to show that it is formed by an antero-internal widening of the shelf primitively internal to the glenoid and thus belongs to the subscapularis rather than to the true reptilian subcoracoideus, as suggested by Gregory and Camp (1918, p. 472). In *Cynognathus* there is no evidence of a separation of the subcoraco-scapularis into two parts. The placental subscapularis is of course dorsal to the subclavius (representing the old sterno-costo-scapularis).

7.—Scapulo-humeralis anterior (Teres minor), Supracoracoideus (Supra- and Infraspinatus), and Coraco-brachialis

Plates XXX, XXXI; XXXIII, origins; XXXV, XXXVII, insertions

a.—Scapulo-humeralis anterior and Supracoracoideus. This set of muscles is of great interest because of its relations to the supra- and infraspinatus of mammals, which, as is well known, have pushed their way up on to the scapula from below.

If we look for the homologues of the supra- and infraspinatus in reptiles, the assumption from position would be that they represent the scapulo-humeralis anterior of such a form as *Sphenodon*, as has been assumed by Watson (1917*a*, p. 55). But that muscle, as noted by Fürbringer (1876, p. 735), is innervated by a nerve partly homologous with the axillary, while the spinatus muscles of placentals are innervated by the suprascapular, clearly the homologue of the supracoracoid nerve of reptiles. Hence it appears that the supra- and infraspinatus represent part or all of the reptilian supracoracoideus, as Fürbringer believed (1876, p. 718).

But *Echidna* renders the problem more complicated, for the infraspinatus (Westling, 1889, p. 46) is innervated to a slight extent by the axillary nerve as well as by the suprascapular; the former also innervates the teres minor, the homology of which has proved a puzzle to many workers (Watson, 1917*a*, p. 56). This suggests (1) that the teres minor is a remnant of the old scapulo-humeralis anterior, (2) that the monotreme infraspinatus also contains elements of that muscle, lost in the placentals, and from this (3) that the scapulo-humeralis anterior and supracoracoideus had a common history throughout. A comparison of the various groups tends to confirm this.

These two muscles, scapulo-humeralis anterior and supracoracoideus, or their representatives, may always be identified by their position. They arise from the external surface of the girdle, bounded dorsoposteriorly by the scapular head of the triceps (which thus sets them off

clearly from the scapulo-humeralis posterior), externally by the deltoid and pectoralis, and ventro-posteriorly by the coraco-brachialis. The innervation is a double one; the upper portion, by a nerve running anteriorly over the humerus or girdle ("axillary"); the lower portion, by the supracoracoid nerve. This appears to be a primitive condition. (The separation from the coraco-brachialis is in some cases an entirely artificial one, but the two ends of the series have a different history and may be considered separately for that reason.) The primitive insertions seem to have been a fleshy one on the antero-lateral corner of the dorsal humeral surface, followed by a tendinous insertion into the proximal end of the pectoral ridge at the proximo-lateral border of the bone, from which it merges below into the coraco-brachialis region of insertion.

In urodeles are found (1) the precoraco-humeralis, which possesses a similar double innervation, below which is (2) a supracoracoideus with its proper innervation. In turtles there is a supracoracoideus and, at least in *Trionyx* (Ogushi, 1913, p. 389), just anterior to it an "infraclavicularis," which is indistinguishable except for its "axillary" innervation. In lizards and *Sphenodon*, on the other hand, the differentiation into a scapulo-humeralis anterior and supracoracoideus has taken place by a split through the division of the two innervation areas. In the crocodile, the scapulo-humeralis anterior has disappeared entirely, while the supracoracoideus is well developed and runs farther dorsally than primitively. This is interesting as a parallel to the mammalian condition, and in a way has even gone beyond it through the entire loss of the dorsal mass. The placental differs from the monotreme by the loss of the dorsally innervated part of the infraspinatus and of the supracoracoideus proper. (In *Didelphys* there is no separate teres minor.)

It will be seen that in practically no case is there an exact homology of any two muscles; but the homology of the group as a whole seems quite clear.

The chief interest of the fossils in this connection is the question of the rotation of the more anterior and dorsal portions onto the scapular surface to form the infraspinous fossa and the creation of the supraspinous fossa in front of the original anterior edge. In the primitive stage, as illustrated by *Diadectes*, the posterior portion of the group, with the coraco-brachialis, covered the whole of the coracoid plate below. We are unable to distinguish between the three elements involved to any great degree, as the distinction, as we have seen, often rests on the innervation. But we may conclude from the fact that the supracoracoid foramen is more posteriorly placed than in any living animal that the

supracoracoid elements of the muscle group also extended more posteriorly. In the mammalian series, the foramen can be traced forward nearly to the edge of the girdle, which, the mammals show, it eventually reached, freeing the nerve as the supra-scapular.

In *Diadectes*, the most dorsal part of the muscle cannot have extended upward on the scapula beyond the point where the clavicle leaves the edge of that bone. Above this, there would be no room for another muscle under the deltoid; below, the girdle is "set in" to some extent, leaving plenty of space under the clavicular deltoid. The insertions seem to have been on the dorsal surface of the girdle, proximal to the line limiting the lateral head of the triceps, tendinously at the angle of the humerus, and below, on the coraco-brachial surface. The situation in *Dimetrodon* seems to have been essentially similar. This represents practically the position of the three muscles concerned in lizards and *Sphenodon*, except that the foramen has moved anteriorly and the supracoracoid innervation does not extend so far into the ventral mass as the more posterior position of the foramen in the fossils would indicate for the Permian forms.

No pareiasaur girdle is available, but the situation seems to have been similar, except that the elevation of an acromion may have given an opportunity for a somewhat greater dorsal expansion.

In *Moschops*, the acromial region is placed rather high up, and the upper limit of the hollow containing these muscles is a line running diagonally up and forwards from the glenoid, showing a considerable advance. The insertion on the dorsal surface of the humerus appears to be restricted by the developing head and the apparent usurpation by the triceps and brachialis anticus of the entire dorsal surface of the bone; the position of tendinous insertion of the supracoracoideus seems to have been about the same.

The therocephalian and gorgonopsian girdles seem to have been similar in this region, as far as they can be made out from descriptions. In *Cynognathus*, as has been pointed out, the infraspinatus is able to reach the dorsal part of the scapular surface for the first time (Watson, 1917*a*, p. 27; Gregory and Camp, 1918, p. 511) by the eversion of the spine; but, as has been shown by both Watson (1917*a*, p. 28) and Gregory and Camp (1918, p. 511), this girdle is specialized by the stoppage of the groove leading from the lower anterior portion of the scapula up under the clavicle, which undoubtedly was the place whence the supraspinatus developed. On the other hand, the girdle of the dicynodonts, while not permitting the dorsal extension of the infraspinatus, has a small anterior shelf (Watson, 1917*a*, p. 35).

From such a condition, the monotreme or ordinary mammalian condition of the supraspinatus may be readily derived. As regards the monotreme, the extension of the supraspinatus up through the opening between clavicle and scapula to the inner surface of the latter would render the original (proximal) area of origin useless, as the covering clavicular deltoid would not allow room for the reception of additional fibers from this region. Further, the retention of this surface would be a hindrance, because of friction and the necessity of the muscle turning a greater angle from its internal origin than would otherwise be necessary. With the loss of this surface (the lower part of the anterior edge of the scapula and the upper part of the anterior coracoid) a therapsid girdle would be essentially similar to that of the monotremes. We have, unfortunately, nothing which bridges the gap between therapsids and higher mammals to show the formation of the supraspinous fossa.

Watson (1917*a*, p. 55) has homologized the supra- and infraspinatus with the scapulo-humeralis anterior, which we have shown to be impossible because of the innervation. Gregory and Camp (1918, p. 475) doubtfully homologize the infraspinatus with the anterior and posterior scapulo-humeralis; as before, the innervation stands in the way, and the posterior scapulo-humeralis muscle lies behind the scapular head of the triceps while the present group is always anterior to it. The same relation to the triceps renders out of the question any homology of the teres minor with either teres major, scapulo-humeralis posterior, or subscapularis. Fürbringer (1900, p. 430) and Gregory and Camp (1918, p. 470) have homologized the teres minor with part of the deltoid; but it is widely removed from that muscle in origin and insertion, and no evidence for this conclusion is presented.

b.—Coraco-brachialis, brevis and *longus.* The anterior relations of the origin of this muscle with the preceding group has already been discussed. The origin in modern reptiles and probably in primitive forms is from the posterior part of the coracoid plate.

The coraco-brachialis in existing tetrapods usually fills the space on the ventral surface of the humerus between the pectoral insertion anteriorly and the medial head of the triceps posteriorly. A long portion may be distinguished, whose fibers usually rise more posteriorly; this may be absent, as in turtles, the crocodile, and many mammals (*Didelphys*, for example). The area of insertion in all the fossil forms is practically the same; it occupies the proximal ventral one of the four primitive surfaces of the humerus, to be described later. The long portion seems to have a distinct area of origin (reduced in *Moschops* and *Cynognathus*) from a region at the back corner of the coracoid.

8.—Biceps and Brachialis

Plates XXXI; XXXIII, XXXV-XXXVII, origins

These two flexors of the lower limb are closely associated throughout by their common function, innervation, and insertion, the insertion being primitively a common one at the adjoining portions of the proximal ends of the radius and ulna, which are usually marked by rugosities in the fossils. It will be noted that the two muscles have a common action in the primitive forms, in which they converge at an angle, presenting an interesting analogy to the triceps on the opposite surface.

We may discuss the two muscles separately.

a.—Biceps. Present in all reptiles and mammals, and absent in existing Amphibia. In its primitive form it arises from the coracoid plate, passing over the coraco-brachialis to a union with the brachialis. In turtles two heads (as in the brachialis) are often present. In the monotremes there are two heads, both ulnar; in placentals the insertion is radial. The primitive condition is repeated in *Didelphys*, with both insertions. The coracoid origin is retained, in part, at least. The fossils give no evidence of separation of the surface of origin of this muscle from that of the adjacent coraco-brachialis mass.

While the homologies of the muscle are clear, its historical origin is confused by its absence in Amphibia. Authors (as Fürbringer, 1876) have thrown out of court the coraco-radialis proprius of these forms because of its supracoracoid innervation. However, the biceps seems to be intimately related as a superficial portion to the deeper coraco-brachialis, which is in turn related to the adjacent supracoracoideus muscle. The biceps might be considered as a posterior part of a primitively continuous flexor whose anterior part is preserved as the coraco-radialis or, as the frequent presence of proximal and distal bellies suggests, it may have arisen from the same group but in a slightly different way, by fusion of elements of coraco-brachialis and brachialis.

b.—Brachialis. The structure of the primitive humerus will be discussed in another section, tending to show that it originally consisted of four triangular surfaces. It is with one of these that the brachialis is associated, filling the distal ventral surface with its origin (as explained in the next section, a more dorsal origin is impossible) and at the extremity meeting the biceps to run to their usual common insertion. This typical condition is traceable in all the fossil forms considered. With the tendency to place the two ends of the humerus parallel, the distal portion of this surface tends to be more directly ventral; but proximally the area of origin curves up dorsally over the surface of the humerus. This con-

dition is closely approximated in all living forms. Variations in insertion are found; in the turtle, there are two parts to correspond with the biceps split. The monotremes possess the double insertion, but in many mammals it is merely ulnar (it will be noted that here the biceps is radial only). The origin in therapsids is large, occupying nearly one-half the (apparent) dorsal surface, above the delto-pectoral ridge; and thus separating the deltoid widely from the triceps.

9.—Triceps

Plates XXXII; XXXIII, XXXV, XXXVII, origins

The general reptilian and amphibian condition of the triceps is that of a great extensor consisting of two main masses: (1) a median portion, with a long head from the coracoid (or its dorsal replacing ligament), passing posterior to the subcoraco-scapularis and latissimus, and a short head from the medial side of the humerus; (2) a lateral portion, with a long head from the scapula near the joint capsule and a short head from the lateral surface of the humerus. These conditions are found duplicated in a very striking fashion in the fossil forms under consideration. The dorsal surface of the humerus consists of two approximately triangular surfaces, at a sharp angle to one another in primitive forms. The posterior (distal dorsal) one, with a distal base, is unquestionably the point of origin for the medial humeral head. The coracoid origin is best seen in *Dimetrodon*, where it is a large tuberosity, to which the proximal apex of this surface is directed. This may be traced back through some of the lower pelycosaurs to a roughened surface in the cotylosaurs, just above the posterior end of the glenoid. Of the lateral portion, the scapular head in primitive forms must have arisen from the lower part of the ridge bounding the scapular blade posteriorly or a rugosity posterior to that ridge. The lateral humeral head arose from the proximal dorsal surface. In a large number of forms, good material shows a line running from the latissimus insertion anteriorly across this surface toward the delto-pectoral crest. I believe that this was the proximal end of the area of origin and separated the muscle from the scapulo-humeralis anterior insertion. This area cannot belong to the brachialis; it is at a sharp angle to the general area of origin of that muscle, almost 180 degrees in *Cricotus* and *Archeria*. Further, an *Eryops* humerus shows a distinct concavity distal to this line, as if for the reception of the head of a muscle. In the therapsids and mammals this area has apparently crowded out the scapulo-humeralis anterior and reduced the origin of the latter to a small area near the head; this is in contrast, however, to the reptilian condition.

I have mentioned the way in which the two portions meet at an angle for their insertion on the olecranon, or the universally roughened head of the ulna representing this. This condition is retained in living reptiles, except that the coracoid head is lost in turtles. But in the pareiasaurs, therapsids, and mammals, there is reduction and loss of much of the medial mass, apparently correlated with the changed pose of the limbs. No known therapsid or pareiasaur could have possessed a coracoid head (unless the lizard ligament system had been separately evolved), because of the reduced condition of that bone. Similarly, the medial humeral head is reduced proximally with the reduction of the proximal portion of the posterior dorsal triangular surface of the humerus. This is partially true of *Propappus;* in *Moschops* it is practically absent as is the case with all higher forms. Hence it follows (and this clears up the latissimus position as well) that the mammalian medial head is the distal part only of its reptilian predecessor.

10.—Brachio- (humero-) radialis (Supinator longus) and Supinator

Plates XXXII; XXXV, XXXVII, origins

In mammals, *Sphenodon,* some lizards, and the crocodile is found a muscle not elsewhere present, the brachio-radialis or humero-radialis (in *Uromastix* represented only by a ligament from triceps to supinator). It runs from the humerus (superior to the brachialis) to the inner edge of the radius or, as in *Sphenodon,* connecting with the supinator. *Sphenodon* and the stegoceph-cotylosaur-pelycosaur series give the probable explanation, and show the relation of these two apparently unrelated muscles and the part they have played in the formation of the ectepicondylar foramen.

It must be first noted that these muscles, although placed close to the brachialis (including the "supinator longus" of *Echidna*), are sharply differentiated from that muscle; they are innervated dorsally, by the nerves to triceps and extensors, (*Ra*, Fig. 1) while the brachialis is innervated from the lower side of the humerus (*M-C*, Fig. 1).

The process which we see in *Dimetrodon* just proximal to the extensor origin is unquestionably that which fuses with the ectepicondyle to form the ectepicondylar foramen (found in many fossil forms and in all living reptile groups except Crocodilia). In *Sphenodon,* the supinator arises from a similar position, and it probably did the same in *Dimetrodon* (Watson, 1917*a*, p. 5, etc.; but he suggests brachialis anticus as well). If we follow this process back through some such series as *Ophiacodon,*

Diadectes, *Seymouria*, and the typical stegocephs (it is sometimes suppressed as in *Diasparactus*, Case and Williston, 1913, p. 21), we find that it has progressed downwards from a position near the proximal portion of the boundary between the anterior dorsal and ventral anterior humeral surfaces (anterior dorso-ventral line, Plates XXXV, XXXVII), a position from which we would expect the brachio-radialis origin. The probability of a common origin of brachio-radialis and supinator is strengthened by their fusion and common innervation in *Sphenodon*, their close relation in placentals and crocodiles, and the possession by some primitive humeri (*Cricotus*, etc.) of a well-marked ridge in the position of the anterior dorso-ventral line. Apparently, as the shaft of the humerus develops, the brachio-radialis and supinator tend to go to the distal end and associate themselves with the extensors. In the process, a part of the radial nerve is enclosed, with the resulting formation of the ectepicondylar foramen.

There is no homologue of these muscles in urodeles. Possible explanations of them are that they were a radial homologue of the triceps in some primitive condition of the limb before the elbow "got its crook," or that they were primitively, as they later appear again to be, a part of the forearm extensors.

11.—Forearm: Extensors

The urodeles show a generalized condition of these muscles, as a group running from the ectepicondyle and divided into three portions: (1) radial extensor, to the outer surface of the radius and radial edge of the carpus; (2) the extensor digitorum communis longus, to the digits; and (3) ulnar extensor, to the external border of the ulna and the carpus.

The lower cotylosaurs and stegocephalians show a sharp contrast to later types in the presence of a huge extensor crest nearly at right angles to the distal expansion of the humerus, giving the extensors as large an angle as possible to the lower limb (Watson, 1917*a*). This is found in the process of reduction to the general level and fusion with the supinator crest in *Propappus*, the higher cotylosaurs, pelycosaurs, and therapsids. Two ulnar areas may often be discerned, the more lateral for the origin of the abductor and extensor pollicis, the medial for the origin of the pronator profundus. A dorsal radial surface probably was for the radial extensor insertion.

During the change to the mammalian condition, these lower arm insertions have been lost except the anconæus (possibly the remains of the ulnar inserting part), while the ulnar extensor has acquired a new

ulnar head (the crowding in of the supinator has apparently prevented the radial extensor from doing the same). I have found no clear indication of this in the therapsid series.

12.—Forearm: Flexors, Including Pronators

The urodele condition is that of a series of muscles running from the entepicondyle to the flexor side of the limb: (1) radial flexor, to the radius and a short distance on to the carpus; (2) pronators, from condyle and ulna to radius; (3) flexor digitorum communis, to the digits, with accessory heads from the ulna, the detailed homologies of which will not be considered here; and (4) ulnar flexor, to the ulna and ulnar side of the hand.

The reptilian condition shows little change. In the fossils under consideration, the huge entepicondyle for the origin of the flexors (Watson, 1917*a*, p. 15) is one of the most striking features of the primitive types and its reduction can be traced through a number of forms. At the tip of the condyle is a pit in *Diadectes*, *Propappus*, *Dimetrodon*, perhaps for the origin of a tendon in the ulnar flexors such as is seen in *Echidna*.

The insertions of the ulnar flexor, the ulnar head origin of the flexor digitorum communis, and the course of the pronator quadratus may be seen in fossil ulnæ. In reptiles the ulnar insertion may be reduced. In the mammalian line several changes, not apparent in the fossils, have taken place; radial and ulnar insertions are lost (except pronator teres); the flexor communis acquires a radial as well as an ulnar head (not yet present in monotremes) and becomes highly differentiated; the ulnar flexor acquires an ulnar head (the radial extensor cannot do the same without "jumping" other muscles). There seem to be the same tendency for motion down the limb noticed in the extensors.

13.—Grouping of Fore Limb Muscles

We have noted in several places suggestions of relationships between a number of the muscles considered. In the first place, we have shown the relations of scapulo-humeralis anterior, supracoracoideus and coracobrachialis. Again, the deltoid and pectoralis, with adjacent insertions, similar character, and continuous origins, seem related; and this would be even more evident in a primitive form where a large dermal girdle would restrict the deltoid to a more ventral origin. These seem to be primitively in position an anterior superficial portion of the same mass as the first group mentioned. These also seem to be related to the biceps and brachialis, which in turn lead to the flexors of the lower leg.

On the other hand, the subcoraco-scapularis and scapulo-humeralis posterior seem to have the latissimus (with teres major) as a more superficial portion, with a usually closely related insertion; this group is in turn embraced primitively between the two great heads of the triceps; this leads again to the supinators and extensors.

This conception leads to the idea that the primitive tetrapod arm musculature consists of two great groups, one of which originated on the coracoid plate and the ventral portion of the dermal girdle as the primitive ventral group, the other reaching the arm dorso-posteriorly, above the glenoid, from within as the primitive dorsal group (Fig. 1). If we turn to the bony fish (Pychlau, 1908), we find two similar groups; the abductors arising from the ventral plate and the ventral portion of the cleithrum, and the adductors from the "mesocoracoid" region, dorso-posteriorly (Fig. 4). This suggests the possibility, which will be considered further under the bony elements, that we might homologize these two great masses of the fish and the tetrapod, although the subdivisions would not of course be distinguishable.

(1) Primitive dorsal (fish "adductor") group.—Subcoraco-scapularis, scapulo-humeralis posterior, latissimus dorsi (including teres major), triceps, supinators, extensors.

(2) Primitive ventral (fish "abductor") group.—Deltoid, pectoralis, scapulo-humeralis anterior (teres minor), supracoracoideus (supra- and infraspinatus), coraco-brachialis, biceps, brachialis, pronators, and flexors.

FORE LIMB, BONY ELEMENTS

1.—Dermal Shoulder Girdle

Plates XXXIII and XXXIV

The fact that we have no living tetrapod with a full set of dermal elements has already been commented on. But without question, as the crossopterygian evidence shows, the ancestors of the tetrapods were furnished with a well-developed dermal girdle, and, as seems probable from *Eusthenopteron* and dipnoans, with but a small cartilage bone girdle (Bryant, 1919, p. 19, etc.). The evidence of the living ganoids is that the dermal girdle possessed, on its anterior side, the insertions (wholly or partly) of the trapezius, superficial levator and hyoid muscles and, as is shown by ganoids and teleosts, it gives origin, on its postero-ventral edge, to part of the superficial abductor of the fin, comparable with the deltoid (Fig. 4).

As a supporting structure, it bound the fin bases to the head through the attachment to its inner sides of the primary girdles, and ventrally connected the two girdles. A change to land locomotion would of necessity profoundly alter these relations. A girdle firmly attached to the head would be a handicap on land, since movements of the head and of the girdles would mutually interfere. Furthermore, the great strain upon the girdles caused by raising the body from the ground would put a connection between limb and body by way of the dermal girdle at a disadvantage; the weight of the body would have to be transferred first to the dermal girdle, from that to the primary girdle, and then to the limb. As explained below, this function was taken over by the primary girdle.

With this loss of function, we expect, and find, a dwindling of the dorsal part of the dermal girdle, and the connection with the head only found or suggested, so far as I know, in *Bratrachiderpeton*, and *Keraterpeton* (Watson, 1913, p. 955). Ventrally, however, the clavicular bridge between the two sides of the girdle would still be of use in a slow moving animal; and the connection is strengthened by a new element, not present in fish, the interclavicle.

In respect to musculature, the dorsal portion, the cleithrum, would seem to have preserved its original relations to the trapezius on one side and to the deltoid on the other. The primitive type appears to have had a T-shaped bone, the anterior "prong" connecting with the head (through the post-temporal); the posterior "prong" remains, giving, in *Diadectes*, as in many Rachitomi, the capping type of cleithrum, embracing the front and upper edges of the scapula. This suggests that the trapezius followed this bone in its backward extension following the loss of the head connection. The deltoid seems to have followed the ventroposterior edge of the bone in its retreat dorsally and anteriorly. Ventrally, the clavicle retains part of the deltoid origin. The interclavicle gains prominence with the development of the pectoralis and extends backward in both typical Rachitomi and primitive reptiles to give this muscle its anterior region of origin. While there is nothing new to add to the question of the origin of the sternum, this posterior prolongation would be extremely weak if it were not backed by some sort of sternal structure.

The typical dermal girdle, then, of the primitive reptile is of the type seen in *Diadectes;* a cleithrum which has lost its supporting function and which has not yet transferred its muscular relations to the scapular blade, curving over the upper end of the scapula; clavicles curved in a quadrant shape, reduced above at the cleithral articulation, still ex-

panded ventrally to lay over the head of the interclavicle, and offering an origin to the deltoid posteriorly and hyoid muscles anteriorly; interclavicle expanded anteriorly for the clavicular articulations, and with a moderate backward process for the pectoralis origin. This description would apply nearly as well to any of the generalized Rachitomi, as *Eryops*, or *Cacops*.

The further history of these elements is for the most part one of reduction, in which they are paralleled in the Amphibia (except for the secondary formation of huge ventral plates in later aquatic Stegocephalia). The function of the cleithrum here is merely for the muscular insertions and origins mentioned. These were later transferred to the scapula. The capping cleithrum is not found beyond the near relatives of *Diadectes;* even *Limnoscelis*, which is similar in other parts of the skeleton, has a small cleithrum, while the clavicle reaches far up the front of the scapula; while in *Seymouria*, also close in most of the appendicular skeleton, the cleithrum had disappeared. It has apparently vanished in many or all Captorhinomorpha, in *Procolophon*, and, as far as known, in all pelycosaurs except some clepsydropids, and in *Edaphosaurus*. Most pareiasaurs still retained one, as do members of the Dinocephalia, Gorgonopsia, ? Therocephalia, and Dicynodontia (Watson, 1917*a*, pp. 20, 31, etc.). The trapezius seems to have followed the bone during its reduction to the condition of a small splint on the anterior edge of the scapula before transferring its origin to the latter. It will be noted that the anterior border of the reptilian scapula and the spine of the mammalian scapula are the functional homologues of the primitive cleithrum.

The ventral elements have undergone little further reduction; they are of practically the same pattern in all Permian forms and are but little changed in lizards, *Sphenodon*, and monotremes, and still present, although much modified, in the Chelonia. There is no sign of reduction in any of the mammal-like reptiles. Their presence seems indicative of slow and regular terrestrial locomotion; it is only when the animal attains speed, accompanied by sudden impact, or agility in arboreal life (both requiring a loose shoulder girdle capable of free motion and the transference of strain to the body independently of the other half of the girdle) that the strength afforded by the clavicular arch becomes a hindrance and is given up. This has apparently been done independently in a number of lines, such as the chameleons, dinosaurs, crocodiles, and mammals; but in many of the last, the loosened clavicles have been retained.

2.—Primary Shoulder Girdle

Plates XXXIII and XXXIV

The shoulder girdle of the typical bony fish (Pychlau, 1908) consists of: (*a*) a scapular portion of small extent lying underneath, and firmly bound to, the dermal girdle; (*b*) the mesocoracoid arch, above the fin articulation, and bracing it, part of the adductor muscles originating on the arch, the others running through it from the inner surface of the girdle; (*c*) the fin articulation; (*d*) below this and the scapular portion, a coracoid plate, placed inward at an angle from the scapula, and free from the dermal girdle, giving origin to most of the adductors.

The type from which the tetrapod girdle has been derived was in all probability not far from this, and the two may be directly compared (Fig. 4). In the stage of the typical Rachitomi and primitive cotylosaurs, the girdle consists of: (*a*) the scapular blade, now nearly free externally from the dermal girdle, and extending far dorsally; (*b*) a supraglenoid buttress, sharply marked off from the scapular blade; (*c*) the glenoid below this; (*d*) a coracoid plate lying below the glenoid and the scapular blade, set off at an angle from the scapular blade, and everywhere free from the dermal girdle. We may follow the history of these parts separately.

a.—The Scapular Blade. In *Eusthenopteron* (Bryant, 1919, p. 19), as in most of the bony fish, there is practically no extension dorsally of the blade of the scapula; in the terrestrial stegocephs and in the primitive Reptilia, the scapular blade is very well developed. The probable explanation for this development has been suggested above, namely, support for the body. The hind limb has gained this support by the union of ilium and vertebral column. The problem in the fore limb, however, is more complicated; a union directly with the axial skeleton would entail the same disadvantages (in connection with the head) that the old dermal support had (at least in primitive forms with short necks); and, besides a mere support for the weight of the body, the shoulder must adjust itself to the effects of the propelling force of the hind legs. This difficulty has apparently been overcome by the differentiation of the serratus series, thus affording a muscular rather than a bony connection in the trunk. A dorsal growth of the scapula would give a longer distance for the play of the muscles and would give the "underslung" condition of the thorax.

It will be noted that this explanation of the growth of the scapular blade is concerned with the inner surface of the bone alone; and that this is the true explanation finds confirmation in the fact that there is no

known muscle, apart from the upper part of the deltoid (which was confined to the cleithrum or a position close to it), which could have originated from the outer surface of the blade at this stage; externally it was otherwise a bare expanse of bone.

In connection with this, we have noted that stout bodied forms, such as *Diadectes*, and *Eryops* among the Stegocephalia, possess "uncinate processes" on the ribs in the region of the shoulder, which Williston (1912, p. 463) suggested articulated with the scapula. As previously mentioned, they probably served as points of origin for the serratus anterior.

Further changes have occurred to the scapula apparently for three reasons: (1) dermal girdle reduction, affecting the dorsal portion and anterior edge; (2) loss of the supraglenoid buttress, affecting the posterior and internal portions; and (3) invasion of the blade by the coracoid plate musculature in the mammalian series.

Changes Due to Dermal Girdle Reduction.—As mentioned in a previous section, the cleithrum has been reduced or lost in all reptiles except the diadectids. This has resulted in a transfer to the blade of the muscles originating or inserting on that bone. Dorsally and externally, the deltoid origin is now on the scapula; the trapezius inserts on the anterior border; and if, as seems possible, the superficial levator had a cleithral insertion, that also has transferred to the scapula, while the other levators and serratus anterior have retained their original position.

Loss of the capping cleithrum seems to be usually accompanied with the shortening of the ossified portion of the scapula and the probable appearance, for the first time in this series, of a cartilagenous suprascapula which of course takes over part of the deltoid, and the levators and serratus anterior. The retention of a cleithrum on the anterior edge is usually associated with a better ossification of the scapula in the forms which possess it; in almost every case of a Permian form with a long scapular blade, the cleithrum is present in that, or a related form. The scapulæ of therapsids are usually of good length, and the late retention of the cleithral splint in this series may be noted.

The invasion from the supraglenoid buttress will be discussed in connection with that portion of the girdle.

Invasion by the Muscles of the Coracoid Plate.—In the living Reptilia, whose mode of locomotion has remained much the same, there has been no such invasion or only a slight one; the deltoid remains in possession of the dorsal portion of the scapula. But in the mammalian line, the changed position of the humerus has entailed a profound alteration

in the position and function of the muscles in the region under consideration; a change which may be compared with the development of the gluteals in the hind leg.

In the primitive type with the humerus straight out from the body, the main support of the humerus was through the coraco-brachialis, which prevented the shoulder joint from "buckling." But in the change to the mammalian type, where the humerus is turned in and parallel to the long axis of the body, a situation arises where this support is not practicable. However, the advantageous position of the insertion of the more dorsal and anterior portions of this muscle mass, on the proximal anterior border of the humerus, enables it to act as a lever of the second class (while aiding in the advance of the body by depressing the humerus distally) since its humeral insertion is anterior to the glenoid. But this advantage will only be retained if the area of origin moves upward in proportion as the humerus shifts to a vertical plane. Further, while the supporting function has been partly shifted to the bone by the more vertical position of the glenoid, it will be noted that this same set of muscles also has the old supporting function of the coraco-brachialis. Again, the most dorsal portion of the mass, the scapulo-humeralis anterior, has a more distal insertion which prevents it from being effective as an extensor; and we have already noted that it is practically lost in mammals, only existing as the teres minor.

As has already been mentioned, the invasion proceeded along two courses: (1) directly up the blade, as teres minor and infraspinatus, limiting the trapezius and deltoid to the anterior edge (spine); and (2) by working up anteriorly, beneath the clavicle to the internal surface of the blade, or by building up a new surface anterior to the old anterior edge of the scapula as the supraspinous fossa (Watson, 1917*a*; Wilson and McKay, 1893). The formation of the infraspinous fossa seems to have been accomplished, to start with, by the more dorsal position of the line marking the upper limit of the coracoid plate (this is seen in *Moschops*), and, secondly, by the eversion of the acromion and spine. The acromion is seen in pareiasaurs (this is probably an independent evolution) but in the therapsids is seen only in the anomodonts and cynodonts; and it is only in the latter that the spine is everted, thus allowing the infraspinatus to reach fully up the blade. As would be expected from the monotremes, the evolution of the supraspinatus took place at a later period; there is no therapsid with a supraspinous fossa. But, as Watson has pointed out, the anomodonts are interesting as showing a small ledge extending up under the acromion from the coracoid plate which was undoubtedly the beginning of this surface.

The main steps in the evolution of the scapular blade are, therefore, seen to be: (1) taking over of supporting function from the cleithrum; (2) taking over of the cleithrum's further muscular connections; (3) invasion from the supraglenoid buttress in reptiles; and (4) invasion by the muscles of the coracoid plate in therapsids and mammals.

b.—The Supraglenoid Buttress. This is marked off sharply from the scapular blade. Externally it presents a triangular surface slanting upward from the anterior half of the glenoid, pierced by a foramen (primitively large), the supraglenoid of Williston (1909, p. 648), and with its internal side extending backward above the posterior portion of the glenoid. Internally, the buttress extends down and anteriorly, with a large cavity (subscapular fossa) anterior to it, from which the supraglenoid and supracoracoid foramina arise, while posteriorly it merges into the internal surface of the coracoid plate.

It is, of course, impossible to escape the close comparison with the mesocoracoid bridge, despite the fact that the centers of ossification in the teleosts are differently distributed. But, whereas in fish the deeper adductors arise within and extend out through the homologue of the supraglenoid foramen, it is highly improbable that in the primitive tetrapod this was the case, because of the difference in the direction of movement of the limb; in an antero-posterior movement the muscle could have very little play. Watson (1917*a*, p. 2) suggested that the joint tissue may have extended through it; Williston has demonstrated its presence as a foramen for a blood vessel in some lizards (1911, p. 389). At all events, it had become rather small by the time we first see it in the reptiles, and the only remains of the primitive short dorsal muscles is the subcoraco-scapularis which arose from its outer surface, the supraglenoid buttress under consideration.

The supraglenoid foramen becomes further reduced in size, in captorhinomorphs, in *Ophiacodon,* and in *Edaphosaurus;* in the poliosaurs and clepsydropsids it has its external opening shifted to the outer surface of the scapula; in *Casea* it has vanished, although the glenoid region is of the same type. One fragmentary girdle, assigned to *Theromus* by Seeley (1895*a*, p. 152), is the only described South African form with a supraglenoid foramen. (?Amphibian?)

We have no certain transitional type to that of modern reptiles. The finished product shows that dorsally the buttress has been inherited partly by the inner surface, partly by the posterior edge of the outer surface of the scapular blade; for the original subcoraco-scapularis is now represented internally by the subcoraco-scapularis proper, while the

posterior outer surface is occupied by the scapulo-humeralis posterior, a part of the same mass. The scapular head of the triceps is still farther anterior in most cases, instead of occupying a position on the modern posterior border. We have discussed in a previous section the probable falling away of the back border of the buttress towards the inside, with the formation of the sterno-scapular ligament, and the invasion of the internal surface by the postero-ventral portion of the subcoraco-scapularis.

In no mammal-like reptile is there any indication of this surface; even in *Moschops*, there is only a short round transition above the glenoid between inner and outer surfaces. The position of the triceps head and the subscapularis of mammals show that the surface has turned inwards, and that the old posterior edge of the scapular blade has been retained (the dorsal external expansion of the subscapularis in monotremes is probably secondary).

c.—The Shoulder Joint. The peculiar nature of the glenoid of the characteristic American Permo-Carboniferous tetrapods has long been recognized. Its function may perhaps be better understood through a general consideration of the origin of the tetrapod limb.

While the hind limb is principally concerned with advancing the body and not so much with support, the latter function is very important in the fore limb. It must bear the weight of the very heavy head and thorax. Manifestly, the simplest type of limb would be that of one segment, with some sort of supporting structure, or hand, at the end. But it is obvious that such a crutch-like arrangement would cause a great loss of energy through the upward swing and sag at every step. This has been overcome by the use of two segments, of which the proximal one, the humerus, is mainly concerned with the fore and aft motion, the distal, radius and ulna, is more concerned with support. But the motion of the humerus cannot be a purely fore and aft one, for the action of the radius and ulna still demand that the humerus be raised and lowered somewhat; and, further, a rotation of that element is required in order to preserve the articulations of the humerus with the forearm, and is further caused by the action of the forearm muscles on the condyles of the humerus.

As noted by Watson (1917*a*, p. 13), the main motion of the fore limb for the advance of the body is one from a position in which the humerus is advanced and the forearm extended to one in which the humerus is in its most posterior position and the forearm flexed.

Watson has assumed that the glenoid is a single screw-shaped surface, but this seems rather improbable, because of its great length. The

opposing surfaces, on this view, are segments of rather large circles, and any considerable movement of the distal end of the humerus would be out of the question, as he notes. Any motion of more than about 20 degrees would cause the humerus to cut the muscular surfaces at the anterior and posterior edges of the joint. The joint capsule and ligaments would be greatly strained; for example, in *Diadectes* a twenty-degree movement would displace a point on the articular surface of the humerus from a corresponding point on the girdle about an inch and a half sideways. Further, motion over the whole surface would entail a great deal of friction.

Although it is hard to be certain, due to the amount of cartilage which probably covered the joint in life, it seems probable that there were two partially separated articular surfaces, and not one, in the shoulder joint. A well-preserved humerus, such as that of *Dimetrodon* (Fig. 3), sometimes shows on its articular surface a ridge running posteriorly and ventrally and separating two surfaces. One commences broadly at the anterior dorsal edge and dwindles as it curves underneath to terminate at a distinct notch on the under side of the bone. The other commences behind the first and continues dorsal to it to the posterior end of the articular surface. No such ridge can be found on the glenoid, but it will be noted that anteriorly there is a broad beginning of the glenoid, followed by contraction of the surface, and then by a sudden expansion. This change in the width of the articular surface, found in all types, is difficult to explain on the theory of the unity of the surface, but fits perfectly with the idea of two distinct surfaces. The second expanded surface is the anterior termination of the second surface of the joint.

The screw type is present with remarkable uniformity throughout the American cotylosaur and pelycosaur series, most of the apparent discrepancies probably being due to the presence of greater or lesser quantities of cartilage on its surface. We have no transition to the modern reptilian condition; here, as otherwise, the *Arræoscelis* girdle does not shed any sure light.

The African reptiles, as well described by Watson (1917*a*, fig. 26, etc.), show a sharp contrast, although somewhat of an intermediate type is found in the pareiasaurs. Here the "screw" is still present, although in a much shortened form. The therapsids show a progressive series of forms in which the screw is almost obliterated; the vertical plane of motion of the humerus tends to bring the two primitive glenoid surfaces into parallel positions as the posterior and anterior portions of a single surface running from the dorsal side of the humerus to the ventral,

extending only slightly posteriorly below, and with a corresponding surface on the glenoid. This would apparently lead to a disappearance of any distinction between the surfaces, functionally alike.

d.—The Coracoid Plate. This extends antero-posteriorly below the scapular blade and glenoid, is turned in at a sharp angle from the former, and gives origin, in the main, to the great ventral group of short humeral muscles (scapulo-humeralis anterior, supracoracoideus, and coraco brachialis) as well as the biceps. In position and function this surface may be compared to the pubo-ischiadic plate in the pelvis.

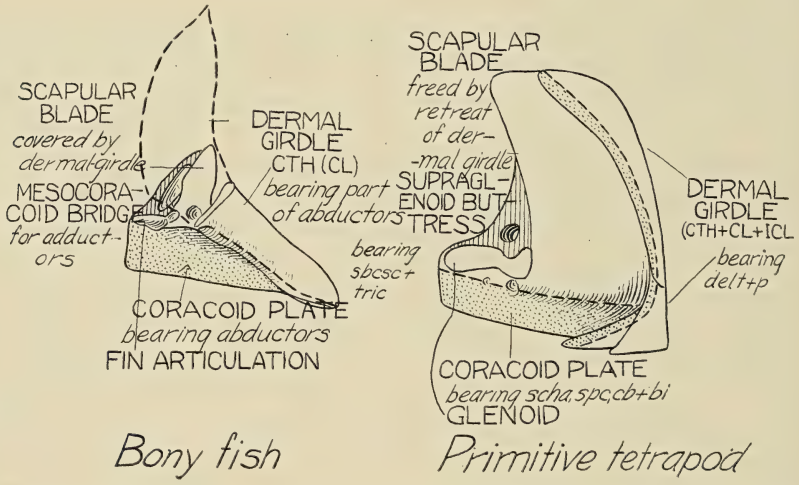

Figure 4. Diagram to show comparison of fish and tetrapod shoulder girdles. In the fish (left) the upper part of the dermal girdle has been cut away to show the scapular blade beneath. The primitive dorsal and ventral masses of the limb musculature are indicated. The dorsal mass in fish arises from the mesocoracoid bridge and the region internal to it; in tetrapods from the region of the supraglenoid buttress. The ventral mass in either case arises from the coracoid plate and the dermal girdle.

This region, which gives rise to the abductors, is even more clearly defined in the bony fish, since the small scapular blade is mainly covered by the dermal girdle (Fig. 4). In the primitive reptilian and rachitomous types, however, the reduction of this secondary girdle had progressed so far that it is only the anterior border of the scapular blade which is covered by dermal elements. The upper boundary is marked by a change in surface which frees the anterior border from the clavicle (this is the acromial equivalent) and at the same time allows room for musculature beneath the deltoid. This line usually runs across the scapula forward from the anterior edge of the glenoid; and it will be noted that the boundaries of the plate are thus not exactly those of the coraco-scapular suture.

The anterior and ventral borders often show surfaces which indicate cartilagenous extensions, the exact extent of which it is difficult to determine. Ventrally, it is probable that in most if not all cases they continued the plate to the mid-line or nearly to it; Williston (1916*a*, p. 182; 1917*a*, fig. 6; etc.) has found well-articulated specimens, the coracoids touching. Anteriorly, it will be noted that in no forms which may be considered at all primitive is there ever shown to be any contact between the coracoid and the clavicles or interclavicle; the anterior extent of the plate and its cartilage is limited only by the extent of development of the muscles which it bears, and may extend forward internal to and beyond the clavicles. This is also the usual lacertilian condition.

The supracoracoid (coracoid) foramen, for the nerve of the same name, is found in the same primitive position as in Stegocephalia, opening widely below the anterior end of the glenoid; posterior to it in both groups is sometimes found a third foramen, the glenoid of Williston (1909, p. 648), the character of which is unknown, but which probably carried a blood vessel. In connection with the supracoracoid foramen may be noted a similarly placed foramen in teleosts (Pychlau, 1908, p. 713) which carries a nerve supplying the abductors.

We have earlier noted the fact that there are few indications of separate portions of this plate for the muscles originating from it, except for the usual presence of a small distinct surface posteriorly for a coracobrachialis longus.

Internally, the plate region presents at its posterior end a concave surface, running down and then in from the ridge above the glenoid. It is pierced by the small internal opening of the glenoid foramen and offers insertion for the axial musculature. Opposite the anterior edge of the glenoid, the surface falls away sharply for the subscapular fossa which gives origin to the supraglenoid and supracoracoid foramina. In front, the plate is much thinner and corresponds in curvature to the outer surface, and probably had no musculature.

In modern reptiles, where the mechanics of locomotion are similar, the coracoid plate has remained much the same except for the dorsal posterior loss of surface mentioned in connection with changes in the glenoid region. It gives origin to the scapulo-humeralis-supracoracoideus-coraco-brachialis mass and the biceps. An item of interest is the fenestration of the lizard coracoid, which seems to correspond to the areas of origin of these muscles and forms an analogy to the fenestration of the skull which is associated with the distribution of the jaw muscles.

We have already discussed the changes in supporting function which have rendered the muscles of the coracoid plate of little value *in situ* in the mammalian type of locomotion and have led to their invasion of the scapular blade. This has been accompanied by a reduction of the coracoid plate, progressive stages in which may be observed in the therapsids from *Moschops* to *Cynognathus*. In monotremes, the plate is of approximately the same extent, except for a loss of the anterior dorsal portion. In higher mammals, we have only a "nubbin" remaining, as the coracoid process (for the origin of the biceps and reduced coracobrachialis). The glenoid foramen disappears above the cotylosaurs.

The suture between scapula and coracoid has already been described in every group of cotylosaurs except the diadectids (Watson, 1917*a*, p. 5); and one of the *Diadectes* shoulder girdles in the American Museum indicates this suture. In this, the cotylosaurs present a contrast to the known Rachitomi, in which there is no indication of any division of the shoulder girdle. The question of the number of coracoids is more complicated. Pareiasaurs, captorhinomorphs, and *Procolophon* have two elements, as does *Limnoscelis*, the girdle of which is otherwise similar to that of *Diadectes*. Only in this latter form and in *Seymouria* is there a single element. This is, as Watson (1917*a*, p. 49) has pointed out, a primitive character.

The evolution of a posterior coracoid in addition to the primitive anterior one has thus taken place within the Cotylosauria. The two elements are found in almost all pelycosaurs, as well as all therapsids. Modern reptiles, however, have but one. We may either assume, with Watson (1917*a*, p. 59), that these groups sprang from a form which had never developed a posterior coracoid, or, with Williston (1911, p. 99), that they have secondarily lost the posterior coracoid. Watson's argument would necessitate splitting off all living and most fossil reptiles at the very base of the cotylosaurs.

Williston finds no ossification in the posterior coracoid region of *Varanoops* (1911, p. 99) (the related *Varanosaurus* has a well-developed bone (Watson, 1914*a*, p. 305)), and Case and Williston demonstrate (1913, p. 50) its late ossification in *Ophiacodon*, suggesting loss of a separate center of ossification. In either case, it will be noted that it is the anterior coracoid which is retained by the reptiles.

The monotreme has two elements similar in appearance to those of the therapsids, and hence it would appear that the anterior coracoid (the "coracoid" of living reptiles) is the anterior element (epicoracoid or precoracoid) of monotremes (Broom, 1912; Watson, 1917*a*, pp. 49–52).

The posterior element of the monotreme girdle is generally recognized as the true marsupial and placental coracoid.

But it will be noted that this destroys the homology of the mammalian coracoid with that of living reptiles; and attempts have been made to preserve the older conception. The evidence for this point of view has been well presented by Gregory (1918, pp. 545–552), restated by Hanson (1920), the main lines of argument being: (1) the anterior reptilian coracoid is similar in position to the posterior one of monotremes, (2) the epicoracoid of monotremes is the "epicoracoid" of lizards and *Sphenodon*, and (3) the muscular origins prove these two homologies. No one of these arguments will hold.

(1) The argument for position is summed up in Hanson's statement (1920, p. 399) that "it is hard to imagine any rotation or migration of this element (the posterior coracoid of reptiles) which would bring it from a position distinctly posterior of the glenoid to its present distinctly anterior one." This statement can only be made in a comparison of living reptiles and higher mammals, with a disregard of phylogeny. The posterior coracoid of reptiles when present is never posterior to the glenoid. In primitive reptiles it occupies the posterior portion of it; in the therapsids, it almost or entirely excludes the anterior element from the glenoid, as Broom (1912) and Watson (1917, p. 50) have demonstrated. Neither is the acknowledged coracoid anterior to the glenoid in the monotreme; it occupies it. The relation of the two monotreme elements coincides almost exactly with those of higher therapsids, except that the antero-dorsal portion of the coracoid plate is missing in the monotremes. I have in a previous section suggested the reason for its absence.

(2) The presence of the epicoracoid in monotremes must be explained away. Gregory (1918, pp. 545, 547) maintains that this bone is the homologue of a cartilage known to exist anterior to the bony girdle in some extinct forms and a similarly placed cartilage or calcified cartilage in lizards and *Sphenodon*. It is admitted by Hanson (1920, p. 335) that we have nowhere else except in monotremes any ossification to fit in with this theory. Such a cartilage was certainly not always present in extinct reptiles; I have seen some clepsydropsids with a finished outline to the bone in this region. In lizards and in extinct forms where it is believed to be present, this cartilage seems to be merely an unossified peripheral portion of the coracoid, of which it is functionally a part. This contrasts sharply with the monotreme epicoracoid, a bony element quite distinct from the coracoid.

In this connection, this theory ignores the fate of the posterior coracoid, as Gregory notes (1918, p. 547). Between therapsids and monotremes, it necessitates a sort of March Hare's tea party, in which every element shifts one place: (a) an *ossified* epicoracoid suddenly appears and takes the place of the anterior coracoid; (b) the anterior coracoid shifts into the position of the posterior coracoid; (c) the old posterior coracoid is forced out of the glenoid (after having taken it over completely) and disappears.

(3) Argument for homology of bones from muscular origins is extremely dangerous; in this very region we have shown that a radical change in the musculature has taken place. It is stated that the same muscular elements arise from the coracoids of monotremes and *Sphenodon* (Gregory, 1918, p. 546). This is only partially true. The musculature found on the modern reptilian coracoid (the primitive supracoracoideus and coracobrachialis) is distributed between the scapula (supra- and infraspinatus), epicoracoid (supracoracoideus), and coracoid (coracobrachialis) in monotremes. It is stated (Gregory, 1918, p. 546) that the same muscles originate from the monotreme epicoracoid as from its supposed homologue in *Sphenodon* (supracoracoideus in part). But a portion of them are found on the scapula in monotremes, as supra- and infraspinatus.

All in all, I fail to see any evidence for this theory which will stand examination, while the therapsid-monotreme resemblances are extremely obvious. As Broom and Watson conclude, the mammalian coracoid seems unquestionably the posterior primitive element, which is hence a true coracoid; the modern reptilian "coracoid" is certainly the anterior primitive element, hence, the epicoracoid or precoracoid of monotremes; and the coracoids of the two modern groups are not homologous.

The history of the primary girdle may be summarized as: (1) the taking over by the scapula of the functions of the cleithrum; (2) evolution of the glenoid and supraglenoid buttress; (3) loss of the latter of these, with invasion of scapula and inside of the coracoid plate by the musculature of the buttress; and (4) reduction of the coracoid plate in the mammals and invasion of the scapular blade by its musculature.

3.—Humerus

Plates XXXV, XXXVI, XXXVII; Figure 5

The primitive humerus, characteristic of both Reptilia and Amphibia of the American Permian is at first sight hard to understand. Proximally, it is terminated by the long curve of the glenoid articulation; distally,

the bone is expanded between the two epicondyles and including the radial and ulnar articulations at an angle which, in such a form as *Diadectes*, is nearly a right angle. This type of humerus is often spoken of as "twisted" and later types as "less twisted." Its universal primitive occurrence, and the presence of transitional types to modern humeri, necessarily leads to the acceptance of this type as the primitive one. Reduced to its simplest form, as perhaps seen best in *Achelomma* (Fig. 5), the primitive humerus was built as a tetrahedron, composed of four roughly triangular surfaces, two having their bases proximally, and two distally, with the planes of these bases at right angles to one another. The four surfaces may be described separately.

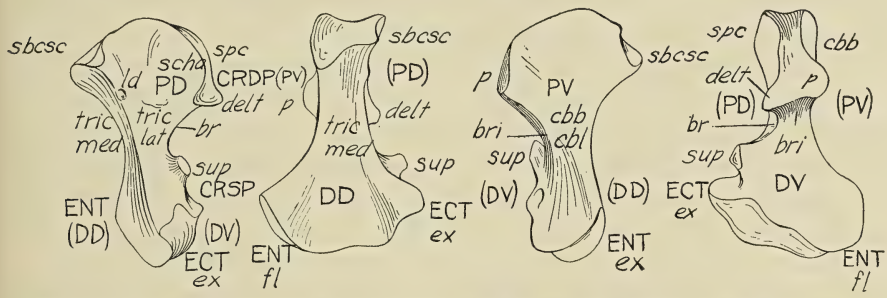

Figure 5. Humerus of *Achelomma*, showing the four surfaces of the primitive tetrahedral humerus (proximal and distal dorsal, proximal and distal ventral, PD, DD, PV, DV) and their relations to the musculature.

(*a*) A proximal dorsal surface, with its base at the curved head, its plane facing antero-dorsally in natural articulation, and its apex at the ectepicondyle. Its anterior border is marked proximally by the supracoracoideus insertion and delto-pectoral crest, then by a ridge (anterior dorso-ventral line) for brachio-radialis origin, separating this surface from the brachialis surface anteriorly and termination at the supinator crest. The posterior border begins proximally with the insertion of the subcoraco-scapularis, followed by the latissimus; then there is a sharp ridge (medio-lateral line), terminating at the extensor crest, separating this surface from the distal dorsal one. There usually runs transversely across it a line (transverse humeral line) from the deltoid to the latissimus insertions (not seen in *Achelomma*); the lateral head of the triceps originated distal to the transverse line; the scapulo-humeralis anterior inserted proximally to it.

(*b*) A distal dorsal surface, having its base between the distal condyles, its apex at the posterior end of the head, and the plane of its surface looking dorso-posteriorly. Its anterior dorsal border adjoins the

last described surface. Its posterior border distally is the huge entepicondyle; beyond this, the border curves in to the ventral posterior corner of the head of the humerus. This surface gave rise to the median head of the triceps. On it is the upper opening of the entepicondylar foramen when this is present.

(*c*) A proximal ventral surface, having its base at the head and tapering out to an end at the proximal end of the entepicondyle. The posterior edge is co-terminous with the last described. The anterior edge is bounded by the supracoracoid insertion, which continues into the pectoralis crest, then down across the gap through which the biceps passes, and on to the proximal border of the entepicondyle. The greater part of the surface was occupied by the coraco-brachialis, the longus occupying the narrow descending distal end.

(*d*) A distal ventral surface. Its base at the distal end, between the condyles, and its lateral boundaries coinciding with those of (*a*) and (*c*). From a beginning proximally at the delto-pectoral crest, it spreads out posteriorly to form the under side of the entepicondyle, and distally is occupied by the radial and the ulnar articulations, while the entepicondylar foramen when present opens posteriorly and proximally to them. This surface, where occupied by muscles, is for the brachialis.

It will be seen that the only major difference between this type and that found in the most primitive reptiles, as *Seymouria*, *Diadectes*, and *Limnoscelis*, is the absence of an entepicondylar foramen, and it is natural to conclude that the one type is directly ancestral to the other.

A complication, however, is caused by the occurrence of flattened types, in which the distal and proximal surfaces, above and below, are in nearly the same plane. This is found in a form, *Archeria* of Case (1915, p. 170), known only from the humerus, which possesses an entepicondylar foramen and is inferred to be reptilian, and also in the humerus assigned to *Cricotus* (Case, 1915, p. 162). This latter is the only embolomerous type of which the humerus is accurately known, and deserves consideration because of the primitive position of the Embolomeri as a whole. But in other features *Cricotus* is usually considered to be secondarily aquatic, and it seems probable that this flattened humerus is also secondary. The similar *Archeria* humerus also seems to belong to an aquatic type.

From our present evidence, then, it seems justifiable to regard the tetrahedral type of the typical Stegocephalia, without an entepicondylar foramen, as the most primitive, and to derive the reptilian humerus from this by the addition of the entepicondylar foramen. This foramen seems

to be caused by a greater development of the flexor musculature, and a proximal extension of their humeral area of origin, which has surrounded the median nerve and blood vessel. Even in *Cricotus*, there is a notch at the proximal end of the condyle which suggests that only a slight growth of the condyle would cause their inclosure. The foramen is found in the Amphibia only in *Diplocaulus* and questionably in *Cochleosaurus*.

The history of the humerus beyond the primitive reptilian condition is concerned mainly with: (1) development of a shaft; (2) development of the ectepicondylar foramen; (3) secondary "untwisting" of the humerus by placing the proximal and distal surfaces in more of the same plane; and (4) reduction of the condyles and their foramina.

There is no shaft, properly, in *Seymouria*, the diadectids, nor *Limnoscelis*, nor in the pareiasaurs, although the humeri of the latter are advanced in other characters. Most of the captorhinomorphs, on the other hand, have well developed shafts, the extreme of which is seen in *Pleuristion* (Williston, 1910, p. 589); they have better developed shafts than many pelycosarus, especially *Ophiacodon*. There is a gradual increase in length in the therapsids, the Dinocephalia having rather short humeri. *Aræoscelis* (Williston, 1910, p. 588) is remarkable for the extreme length of its humerus.

The causes of the formation of the ectepicondylar foramen were discussed in a preceding section. The foramen is primitively absent in all cotylosaurs, except perhaps the pareiasaurs, all pelycosaurs except *Edaphosaurus*, and probably in the "Archosauria" and many other extinct reptiles. It is present in Chelonia, Nothosauria (Seeley, 1895*b*, p. 1017), lizards, "Proterosauria" (*Aræoscelis* and *Kadaliosaurus*, Williston, 1914, p. 126), *Edaphosaurus* (Case, 1913, p. 81) and therapsids (Seeley, 1889, p. 264, and 1895*c*, pp. 30, 45; Watson, 1914, p. 773, etc.) It is lost in mammals and is not often described in therapsids. It is certainly secondarily absent in the latter group in many cases, as in *Moschops*, where the radial nerve clearly ran proximal to the fused supinator crest and ectepicondyle; but I am inclined to believe that its apparent absence is often due to its small size, which has caused it to be left unexcavated. The foramen is not described in pareiasaurs, but I am convinced that some of the group, at least, will be found to possess it; there is no separate supinator crest, and the configuration of the humerus distally resembles that of forms which primitively possessed the foramen.

The placing of the distal plane at nearly right angles to the proximal is correlated with the position of the forearm, which works in a plane which is more nearly parallel to the ground in the more primitive types,

as noted by Watson (1917*a*, p. 13, etc.). When the forearm works in a more nearly vertical position, and one more nearly in the same plane as the long axis of the humerus, the distal plane shifts to preserve its relations, rotating up posteriorly and down anteriorly, hence being more nearly in a horizontal position and more nearly parallel to the plane of the proximal part of the humerus. An early and striking example of this is seen in the pareiasaurs, some of which early acquired a more upright gait (Watson, 1917*a*, pp. 8, 9); in *Propappus*, for example, the difference between the planes is only about 30°. The higher cotylosaurs and theromorphs still retain very distinct surfaces, but the angle is not great, usually varying from about 30° to 60°. This condition is essentially the same in the modern lizards and *Sphenodon*, in most of which a fair degree of "twist" and fairly distinct surfaces are retained. In the therapsids the "untwisting" process is very early and very marked, and leads to an approximation of the two planes, a loss of the proximal part of the distal dorsal surface, and a blending of the other surfaces, so that they are not readily distinguishable in modern forms unless we attempt to determine them from the muscle areas concerned. The proximal part of the distal ventral plane appears as the anterior half of the dorsal side of the humerus (the brachialis origin).

The primitively large epicondyles gave strength to the extensors and flexors by creating an open angle of insertion which was especially necessary in the flexors because of the strain upon them caused by the inclined position of the forearm and the necessity of their exerting a great lifting force (Watson, 1917*a*, p. 15, etc.). In all higher types, the condyles are reduced (except for a probably secondary expansion in digging forms), correlated with a more vertical position of the forearm, putting the supporting function more on the radius and less on the forearm muscles, and smaller angles of insertion, correlated with greater speed and less strength, rendering large condyles unnecessary.

Propappus shows an early example of this reduction, for the first reason; although the humerus is extremely short, the condyles do not extend far beyond the articular surfaces (Watson, 1917*a*, p. 9). Both foramina are probably present, although reduced. In the Captorhinomorpha the epicondyles of the slender humerus are much reduced; even more so than in any pelycosaur, the lower types of this order, such as *Ophiacodon* being only a slight refinement of the lower cotylosaurian type. *Aræoscelis*, with a slender pair of epicondyles, still retains both foramina. In all modern groups of reptiles, with the exception of *Sphenodon*, the old entepicondylar foramen, strangely enough, has disappeared in this

process of reduction, while the new ectepicondylar foramen has persisted in all except the "Archosauria," in which line it is quite possible that it was never evolved. The *Moschops* epicondyles are reduced, although the upper end of the humerus is still well expanded; little more reduction is needed to reach the mammalian condition. The entepicondylar foramen is retained right through to the mammals; the ectepicondylar is lost, apparently independently in different phyla.

The modifications of the humerus from the primitive type may be interpreted thus functionally as for (1) upright pose without inturning of the limbs in pareiasaurs; (2) slenderness for speed without upright posture or inturning of the limbs in higher cotylosaurs, pelycosaurs (slight), *Aræoscelis*, and most modern reptiles; and (3) upright pose with inturning of the limbs in therapsids.

4.—Radius and Ulna

Few points of interest are connected with these bones so far as I have been able to discover in the fossil material. The evidence from modern forms shows that there is little variation in their muscular insertions apart from the mammalian line; and here the evidence is too fragmentary to give us much help.

HIND LIMB, MUSCULATURE

1.—Axial Muscles Acting on the Pelvis

Plates XXXVIII; XLIV, XLV, insertions

As the pelvis is little movable, we are interested here mainly in the pelvic origins or insertions of this group.

The axial muscles of the pelvic region may be divided into (*a*) a dorsal group, above ribs and transverse processes, and (*b*) and (*c*) a ventral group, below. The former group is partially interrupted by the pelvis, the latter completely so.

a.—Dorsal Musculature. The most medial muscles of the back (spinales and semispinales) are never interrupted by the ilium. The more lateral muscles, coming from the trunk as longissimus dorsi and iliocostalis and extending down on to the tail as an extensor caudæ lateralis or abductor caudæ externus, have had an interesting history. In urodeles the ilium is mainly a supporting structure, appendicular muscles arising only near its base. The situation was probably similar in *Eryops*. The dorsal boundary of the appendicular muscles seems to have been a transverse line, sometimes not well defined, running diagonally down across the ilium from a tubercle on the posterior border. Since this line is

about opposite the lower end of the sacral articulation internally, we may conclude that the origins and insertions above this point for axial muscles were those of the dorsal system, that is, the longissimus and ilio-costalis anteriorly and the extensor caudæ lateralis posteriorly, the more medial muscles passing freely above the top of the iliac blade.

The situation in modern reptiles, such as the lizards, is radically different. The limb muscles occupy the whole outer surface; the dorsal axial muscles are restricted to the posterior tip (extensor caudæ lateralis) and an internal shelf above the sacral ribs (longissimus and ilio-costalis). It would seem from a direct comparison with the amphibian condition that, with the growth of the appendicular muscles, the dorsal axial system had simply been pushed off the blade of the ilium. The fossil forms, however, give an entirely unexpected answer. With the growth of the limb muscles, the ilium has folded over; the old outer portion above the transverse line is the internal surface above the sacral ribs, which now offers insertion to the dorsal axial muscles formerly found on the outer surface; the transverse line, originally far down the blade, becomes the definitive dorsal termination of the ilium.

The intermediate stages are well illustrated by the fossils. In *Diadectes*, *Diadectoides*, *?Seymouria*, and *Limnoscelis*, the transverse line is the outer limit of a dorsal shelf, set in some distance from the surface below. In *Pœcilospondylus* and *Ophiacodon* or *Theropleura* this shelf is a trough, with the inner and outer surfaces of about equal height, but tending to have the outer surface higher in *Ophiacodon;* in *Dimetrodon* the shelf has now definitely become a part of the inner surface and the ilium is similar to the lizard ilium.

In mammals, the ilium has not changed greatly from the reptilian condition. The lateral caudal extensor is still found above the sacral ribs on the posterior edge or inner surface, and the longissimus group anterior to this.

b.—Anterior Ventral Musculature. This system terminates in lizards and *Sphenodon* in great measure on a ligament, described by Perrin (1895, p. 78), running from the anterior dorsal extremity of the ilium to the pubic tubercle (the most anterior external point of the pubis). This ilio-pubic ligament is continuous ventrally with the pubo-ischiadic ligament running from the external edge of the pubis over the pubo-ischiadic plate to the posterior border of the ischium. Along this first ligament and its dorsal and ventral insertions are found the posterior terminations of the obliques, pyramidalis, and transversalis, while ventrally the rectus continues back over the pubo-ischiadic ligament to

an insertion on the ischiadic symphysis. It will be noted that the ligament affords space for the emergence of the pubo-ischio-femoralis internus (iliacus and psoas) from the inner side of the pubis. The points of insertion of the ligament (probably variable in development) may be easily inferred in the fossils, as, dorsally, the anterior termination of the upper edge of the reptilian ilium (or its amphibian predecessor, the transverse iliac line) and ventrally the antero-external corner of the pubis, often not exactly determinable because of the presence of cartilage. It is of course impossible to state whether or not the rectus extended back over the ventral symphysis to any great degree.

In the mammals the ligament is retained, as Poupart's ligament. At the ventral end, it will be noted that the marsupial bones have developed medial to the pubic tubercle, and the insertion of the ligament is found, in forms possessing these bones, at the external point of union of pubis and marsupial bone.

In living groups the quadratus lumborum, as an internal dorsal member of this group, originates internally from the ilium below and anterior to the sacral ribs or the ribs themselves. Its origin has thus not been concerned with the changes undergone by the external musculature of the ilium. Gadow (1882, p. 418) refers to this group a large muscle running to the femur in the Crocodilia. This is found nowhere else and its relations to a true quadratus lumborum are questionable.

c.—Posterior Ventral Musculature. From the posterior end of the ilium to the tuber ischii in lizards and other groups is a ligament, ilio-ischiadic, probably the mammalian sacro-ischiadic, beneath which the ischio-trochantericus (obturator internus) and coccygeo-femoral muscles emerge on to the leg and from which part of the tibial flexors arise. This ligament is not as intimately connected with the pelvic attachments of the axial muscles as the anterior ligament. These muscles are divided into several groups, interrupted by the coccygeo-femoral muscles. An external mass (reptilian ischio-caudalis) arises from the tuber ischii and proceeds backward ventrally, being met by a dorsal external group (ilio-caudalis) arising from the transverse processes and, through a connection with the upper end of the ilio-ischiadic ligament, from the ilium. There are (apparently as derivatives of this group) a number of variable cloacal muscles, with which we are not concerned. The tuber ischii may be inferred as the general point of origin of this ischio-caudal muscle in the Permian forms.

In the typical mammalia no caudal muscle originates from this region, which, it will be noted, is posterior to the point where the ob-

turator internus passes out of the girdle, while the flexors of the tail (levator ani) originate from the pubis, ilium, and ischium, anterior to the obturator internus. Nothing of this sort is described in the reptiles, as far as I have found, except in the turtles and for a small slip passing down alongside the rectum in lizards. But in *Cryptobranchus* I find a muscle, similar in its relations to this group in mammals, arising from the ischium anterior to the ischio-trochantericus (obturator internus) and running back internal to the coccygeo-femoral muscles (ilio-caudalis, deep part). In most fossil forms there is a ridge running diagonally upwards anterior to the ischio-trochanteric surface which probably served as an origin for this caudal flexor. Its loss, in lizards, etc., is probably due to the great development of the coccygeo-femoral muscles. It is possible that the small cloacal muscle of lizards already mentioned may be a remnant of this. With the enlargement of the ischio-trochantericus as the mammalian obturator internus, the area of origin has been pushed anteriorly on to pubis and ilium and the upper border of the ischium, always preserving the primitive relations to the obturator internus.

2.—Long Dorsal Muscles to Lower Leg

Plates XXXIX; XLIV, XLVI, origins

These two sets are essentially similar in their primitive relations, the triceps or quadriceps laying anteriorly and running to the tibia, the biceps or ilio-fibularis posteriorly and running to the fibula. In the triceps (quadriceps) is found one case of the double innervations found in all the antero-posterior series in the hind leg.

a.—Triceps (Quadriceps and Sartorius). The general reptilian arrangement consists of: (1) extensor ilio-tibialis (rectus femoris) originating from the ilium; (2) ambiens (sartorius) arising from the pubis; and (3) femoro-tibialis (vasti) from the femur, the three heads uniting to insert into the head of the tibia (or through the medium of a patella in most mammals).

(1) The ilio-tibialis generally originates from a tendon covering the top of the ilium, sometimes fleshily near the anterior edge, and sometimes extending on to the ilio-pubic ligament. The origin may be double, as in many lizards, Chelonia, and crocodiles. In all cases there is a double innervation, from crural and sacral branches. The close resemblance of the pelycosaur ilium to that of the lizards renders a similar origin probable, and from this it may be traced back to the already mentioned transverse line of the ilium of lower forms. Whether or not there was a slight fleshy origin anteriorly cannot be said with certainty.

In the mammals the rectus femoris is a derivative of this muscle. The upgrowth of the gluteals in the therapsid series has apparently restricted the muscle to the anterior edge of the blade. It will be noted that it is the anterior portion of the muscle which has been preserved and, as might be expected from this, the mammalian rectus has a purely crural innervation.

Gadow (1882, p. 381), followed by Gregory and Camp (1918, p. 488), says the ilio-tibialis becomes the gluteus maximus. This might possibly be true in part, but (apart from the peculiar monotreme "gluteus maximus," which is radically different from that found in most placental mammals) the gluteus maximus is clearly related to the deeper glutei in origin, course, and insertion, and has no relation to the triceps. Gregory and Camp (1918, p. 486) would derive the rectus femoris from the ambiens; but, as noted below, ambiens seems to be the homologue of the monotreme sartorius, which is clearly that of higher mammals.

(2) The reptilian ambiens, with an innervation which is always crural, originates from the pubis in front of the acetabulum and below the course of the pubo-ischio-femoralis internus out over the edge of the pelvis (it often receives a slip from this muscle), while the ilio-tibialis is always above the pubo-ischio-femoralis internus. No such muscle is found in urodeles. But the origin of this muscle is not far from the lower insertion of the ilio-pubic ligament, and it is conceivable that it may have traveled down this ligament to its present position from an original dorsal one (Noble, 1922); or the contrary may have been the case and the urodele condition resulted from the muscle shifting upward to give two "ilio-tibial" muscles.

The origin of this muscle (and the pubo-tibialis) in Permian fossils may be always recognized as a roughened area on the pubis anterior to and below the acetabulum. This may be recognized also in therapsids. In the monotremes, the homologue of the sartorius of higher mammals arises from this same position, and hence the homology of the two muscles seems unquestionable. In the higher mammals it originates from the anterior superior spine of the ilium and is not closely associated with the quadriceps. This change of position may be easily accounted for by the assumption that, with the changed position of the leg, it has migrated upward over Poupart's ligament, which here inserts close to the origin of the muscle; it is on the ligament in some marsupials. The sartorius is not a derivative of the true pubo-tibialis (ventralis) (Gregory and Camp, 1918, p. 487), for this is by contrast a ventral muscle with usually an obturator innervation (Frets, 1910, p. 83, Gadow, 1882, p.

351) and a ventral tibial insertion between the gastrocnemius heads. The confusion is apparently due to Gadow's indiscriminate use of the term pubo-tibialis.

(3) Femoro-tibialis (Vasti), in reptiles and mammals a great mass from the shaft of the femur of unquestioned homology. Its absence in both urodeles and Anura suggests that it is truly a secondary acquisition. A clue to its origin is given by *Eryops* and *Ichthyacanthus*, which possess a ridge on the femur some distance above the intercondylar sulcus, manifestly too far up the shaft for any sort of capsular arrangement and probably representing the origin of a small femoro-tibialis. While it is impossible to say that this is the actual beginning of the femoro-tibialis, it would seem probable that it is at least a close parallel. The absence of the muscle in the Stegocephalia is rendered more probable by the general slender build of the femoral shaft, with large posterior and anterior surfaces (for ilio-femoralis and adductor) but little dorsal surface, except proximally for pubo-ischio-femoralis internus. On the contrary, the primitive reptiles have a broad shaft, with probably a wide-spreading femoro-tibialis. Its actual boundaries are not very definite in the fossils; it probably covered most of the dorsal surface of the shaft between the adductors antero-ventrally, ilio-femoralis postero-ventrally, and the pubo-ischio-femoralis internus proximally. Its relations have not changed during the evolution of the mammalia except that the iliacus, psoas and pectineus (old pubo-ischio-femoralis internus) are now anterior rather than proximal.

The principal points in the history of the triceps are, thus, (1) development of femoro-tibialis; (2) displacement of ilio-tibialis in the mammalian line; and (3) shifting of sartorius in the higher mammals.

b.—Ilio-fibularis (Biceps). Its general reptilian and urodele condition is that of a muscle of sacral innervation paralleling the ilio-tibialis posteriorly and running from the posterior corner of that part of the ilium concerned with leg muscles to the fibula, external to the course of the triceps. A similar location may be confidently made in the Permian fossils. There is a roughened area of insertion near the head of the fibula.

In mammals there is at first sight no homologue of this muscle, but, by a process of elimination, the biceps, running from the tuber ischii (with a secondary short head in some forms) to the outer, fibular, side of the leg must be a derivative of this muscle (Gadow, 1882, p. 385, Gregory and Camp, 1918, p. 489). Although reckoned as a ventral muscle and connected with the flexor series, the reptilian flexors cannot

give a homologue for this muscle and never insert on the lower leg on the outer side, the most internal of them inserting between the two heads of gastrocnemius (Plate XLI). The marked change in the origin is easily explained by the existence of the ilio-ischiadic (sacro-ischiadic) ligament, running from the old origin directly to the new one on the tuber ischii. We may assume this change in origin to have been associated with the change in position of the limb. From the nature of the case, we have no therapsid evidence as to when this transfer down the ligament took place.

3.—Dorsal Muscles to the Femur

Plates XXXIX, XL; XLIV, XLV, origins; XLVI, Figure 6, insertions

A series, well differentiated in all known forms, probably representing the deeper layer of the primitive dorsal muscle mass, running from the dorsal side of the girdle to the limb; but with the middle portion now originating from the ilium, the upgrowth of which bone has broken the probable original continuity of the group. This same middle portion presents another case of double innervation.

a.—Pubo-ischio-femoralis Internus (Iliacus, Psoas, and Pectineus). The most anterior of the series, with a crural innervation, running from the interior of the girdle out over its anterior border beneath the ilio-pubic ligament to the dorsal surface of the femur. Its original area of origin would seem to have been a strongly built shelf on the anterior internal surface of the pubis, containing the upper opening of the obturator foramen near its posterior border. This shelf, with the muscle in position, is found in *Cryptobranchus*. A similar shelf is found in *Eryops, Cricotus* (inferred from the shape of the ilium), and in the lower cotylosaurs, as *Diadectes*. The shelf is progressively less well defined in the pelycosaurs (it is not as sharply marked in *Dimetrodon* as in modern lizards and *Sphenodon*) but the narrowness of the pelvic outlet renders it improbable that in these Permian forms the muscle had spread backward over the inner surface of the girdle as it has done in the living reptiles mentioned.

The insertion would seem to have spread out over the whole dorsal surface of the femur in the Stegocephalia as in modern urodeles, with a prominent rugosity near the proximal posterior border of this area for a tendon, such as may be found in existing lizards. In the American Permian forms the tendon is retained, but the growth of the femorotibialis has restricted the dorsal insertion. In *Diadectes* a limiting line may be seen to extend transversely across from the tendon rugosity. In

Dimetrodon the line is pushed further proximally at the anterior edge, and the muscle would thus seem to be cut into two parts at its insertion, a posterior tendon and an anterior portion crowded down the anterior edge of the femur outside of the "internal trochanter." This is similar to the lizard condition.

The original function of the muscle seems to have been to raise and advance the femur. Obviously this cannot be done in mammals by a muscle placed so far ventrally. The area of origin has shifted to a dorsal position, the ilium and the lumbar vertebræ. There is no evidence of this change in any therapsid. The old internal area of origin is still fairly well defined in the highest members of the group; nor is there any trace of a trihedral type of ilium which the monotremes and marsupials suggest as the ancestral mammalian condition. Apparently this change of origin is a late step. The pectineus apparently represents a few fibers left behind in this migration.

The psoas minor inserts on the pelvis. Its point of insertion in the monotremes is that of the origin of sartorius and suggests that it is the same set of fibers of the pubo-ischio-femoralis internus which connected with the ambiens at this same point.

A further change in the area of insertion has also taken place. We have seen that the reptilian condition tended to two proximal areas, one posterior or external, and one on the anterior or internal border. The first area is lost in mammals, the second retained. It will thus be seen that the reptilian internal trochanter is partially a homologue of the mammalian minor trochanter (Fig. 6), both having the insertion of the muscle in question on its outer side but with the difference that the summit is not occupied in mammals, as it was in reptiles, by a portion of the insertion of the obturator externus (pubo-ischio-femoralis externus). The trochanter, and the ridge leading to it, may be seen in some therapsid humeri, often remarkably far over on the ventral surface.

b.—Ilio-femoralis (Glutei and Tensor Fasciæ Femoris). The middle portion of the series, with a double sacral and crural innervation from urodeles to monotremes, but sacral only in higher mammals, except for a partial femoral innervation of gluteus maximus in some cases. The general primitive area of origin in living lower tetrapods and hence in the Permian fossil forms under consideration consists of most of the iliac surface below the transverse line or the definitive dorsal boundary, except for the posterior dorsal corner occupied by the ilio-fibularis. The original area of insertion, comparable to that in existing lizards, urodeles, etc., seems to have been an area bounded postero-ventrally by the great ridge

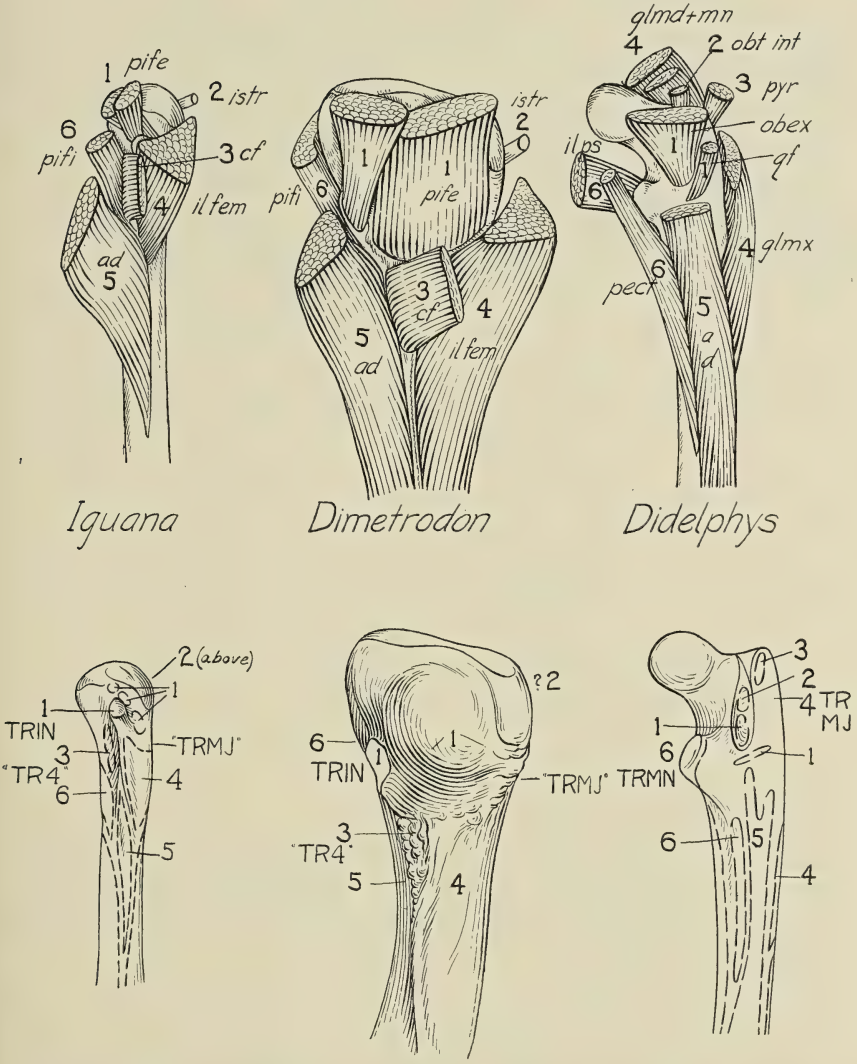

Figure 6. To show the relation of the femoral trochanters (below) and related musculature (above). *Dimetrodon* shows the primitive Y-system, and may be compared with *Iguana* and *Didelphys*. It will be seen that there has been little change in the relative position of the muscles involved, except the mammalian pyriformis. The anterior branch of the Y is the reptilian inner trochanter and, by a change of function, the mammalian minor trochanter. The posterior branch, with the development of the gluteals, becomes the mammalian greater trochanter. The fossa between the two trochanters always contains part of the insertion of pubo-ischio-femoralis in ternus. The junction of the branches is occupied by the insertion of the coccygeo-femoral muscles (fourth trochanter). On either side of the Y-system lie the adductors anteriorly and the ilio-femoralis posteriorly.

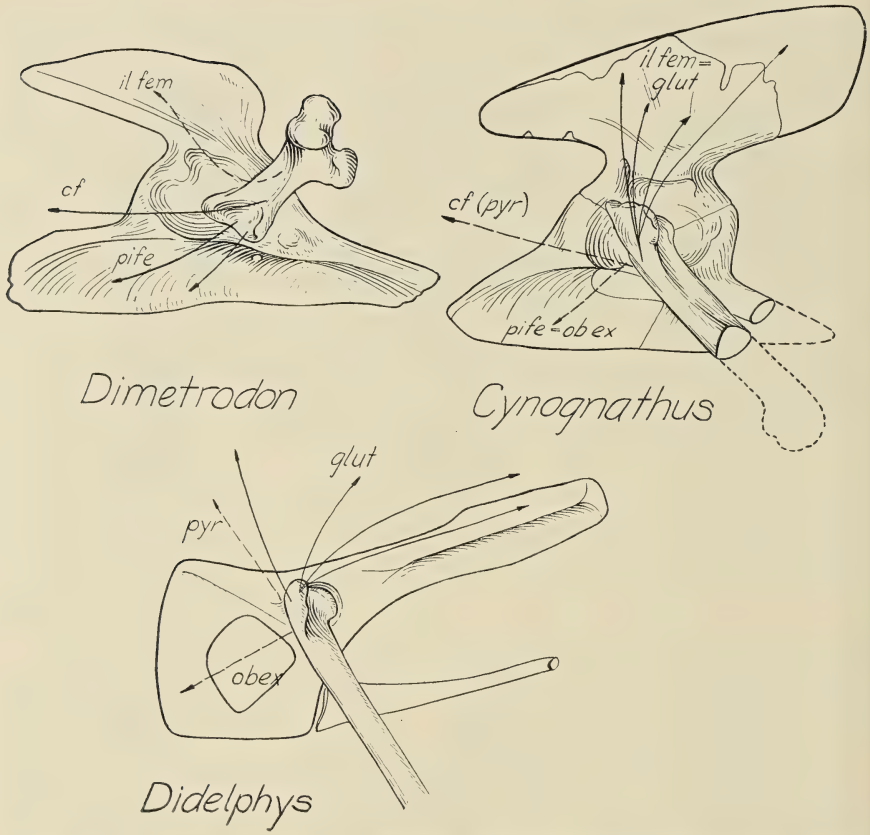

Figure 7. To show the change in the method of supporting the body and extending the femur in mammals as compared with reptiles. In the former the ilio-femoralis has only a small function as an extensor, and support and extension are carried on to a great degree by the ventral musculature. In the mammals the changed position of the femur and development of the greater trochanter transfers these functions to the glutei, enabling them to act as levers of the second class, since the greater trochanter is now posterior to the hip joint.

on the under side of the femur and its posterior proximal branch. Above, there is no clear line of demarcation from the primitive insertion of the pubo-ischio-femoralis internus, and later from the femoro-tibialis (which then occupies this same area). Proximally it abutted on the insertion of the tendon of the pubo-ischio-femoralis internus.

This muscle is of great interest in the mammalian series because of its expansion and differentiation connected with the changes in the position of the limb, analogous to the development of supra- and infra-spinatus in the fore limb (Gregory and Camp, 1918, p. 520). In the primitive type the work of support was performed by the ventral

muscles (Fig. 7). An antero-posterior position of the femur has caused a great loss of this function ventrally. But with the development of the head from the antero-internal angle of the femur the proximal portion of the insertion of the ilio-femoralis, at the posterior corner, was in an advantageous position to exert a leverage and attain a supporting function. This also pulls the femur back, aids much in locomotion, and enables the muscle to retain its old function as well. With this change has come a great expansion in the area of origin. The iliac blade has grown up and forward, giving a greater leverage and pushing the rectus femoris before it. In the Mammalia, a portion of the origin has been transferred to the fascia of the back or tail vertebræ with a secondary reduction of the extent of the ilium. The beginning of such a process may be seen in *Lystrosaurus*, where the posterior portion of the upper edge of the blade is scalloped and apparently in the process of being lost.

The longer portions of the muscle have retained the old position between adductors and vasti on the posterior side of the femur. The proximal portion of the area of insertion, representing the outside of the proximal termination of the posterior branch of the ventral ridge, is developed into the greater trochanter, which is thus seen to be partly homologous with the old posterior ridge. (Fig. 6.)

c.—Ischio-trochantericus, "Ischio-femoralis" or Pubo-ischio-femoralis Posterior (Obturator Internus and Gemelli). A short muscle originating from the posterior dorsal surface of the pelvis and running out under the ilio-ischiadic (sacro-ischiadic) ligament to insert by a tendon into the proximal end of the femur. In primitive fossil pelves (as also in *Cryptobranchus*) there is a small fan-shaped area of origin inside the ischium, converging to the representative of the "lesser sciatic notch." This, with possibly the area just external to this and representing the gemelli, constituted its area of origin. In the mammalian series this area is still well marked in *Moschops;* in some mammals, however, the muscle has spread widely over the inner surface of the pelvis. The small tendon of insertion cannot be recognized with certainty on fossil femora.

4.—Long Flexors

Plates XLI; XLIV, origins

Pubo-tibialis, Pubo-ischio-tibialis, Flexores Tibiales Internus et Externus or Ischio Flexorius (Gracilis, Semitendinosus, Semimembranosus). A complicated series of ventral muscles running from the lower side of the pelvis and generally inserting on the internal

and ventral aspects of the tibia or into the lower leg musculature. While the homologies as a group are always apparent, the various portions are hard to compare. There is a general double innervation, as usual in antero-posterior series, almost altogether sacral in urodeles, with more of the obturator innervation in higher groups.

Primitively the origin is entirely from the pubo-ischiadic ligament, if developed, from the pubic tubercle along the symphysis to the tuber ischii and thence up along the ilio-ischiadic ligament. This type of origin was undoubtedly that of the primitive forms, as it is of urodeles, lizards, and *Sphenodon* today. The typical differentiations are: (1) pubo-tibialis, from the pubic tubercle; (2) pubo-ischio-tibialis (including probably the pubo-tibialis of urodeles) from the pubo-ischiadic ligament; and (3) deeper and more posterior portions, centering in origin around the tuber ischii and the adjacent ligaments, making up the flexores tibiales internus et externus (ischio-flexorius of urodeles). Into this last group, in urodeles, the coccygeo-femoralis longus, as caudi-pubo-ischio-tibialis, inserts.

The insertions are mainly tibial, extending ventrally from the internal to the external border of the bone. In lizards and *Sphenodon* the most internal is the gracilis or pubo-ischio-tibialis extending down the inner side of the tibia, together with a part of the flexor tibialis internus. Next, somewhat shorter and slightly more external, is another portion of the flexor internus, which may bridge the internal head of the gastrocnemius or insert partially at the end of the femur. At the outer ventral portion of the tibia between the two femoral heads of the lower leg flexors when both are developed are found insertions for pubo-tibialis and portions the of flexor tibialis internus and flexor externus, parts of which may also connect with the lower leg musculature. A strong ridge on the inner surface of most American Permian tibiæ indicates the insertion of pubo-ischio-tibialis and the associated part of the flexor internus. There is a tuber on the fibular side of the tibia for the portions inserting in the region.

In mammals, most of which possess the inner femoral head of the gastrocnemius, the gracilis, semitendinosus, and semimembranosus are found to insert on the inner side of the tibia or the shaft of the femur immediately above, and hence we may reasonably homologize them with the gracilis and the internally inserting portions of the flexor internus, (Gadow, 1882, pp. 402, 404; Gregory and Camp, 1918, pp. 489–491) and conclude that those portions (pubo-tibialis and part of the two flexors) which inserted outside of the internal gastrocnemius head have been

lost, no mammalian muscles inserting in this region. These homologies agree well with the origins and innervations of the muscles. The mammalian gracilis has an obturator innervation, as does most of the usual reptilian pubo-ischio-tibialis; the reptilian flexors have a double innervation, as do the semimembranosus and semitendinosus of monotremes (sacral purely in higher forms). The gracilis has the same general area of origin as its reptilian equivalent; the reptilian flexors originate near the tuber ischii, as do their mammalian equivalents.

It is of course impossible to determine the exact distribution of the various portions of the group in the fossil forms; the reconstructions given are based on a comparison of the various reptilian conditions. It will be noted that the insertions never pass external to the external femoral head of the lower leg flexors, as would be necessary were biceps a part of this group.

5.—Adductors, "Ischio-femoralis" or Pubo-ischio-femoralis

Plates XLII; XLIV, origins; XLVI, Figure 6,insertions

Apparently representing a middle layer of the primitive ventral musculature, running in modern reptiles and urodeles from the pubo-ischiadic ligament, internal to the long flexors, to the antero-ventral side of the shaft of the femur. The innervation, as with all these series, is generally a double one, obturator and sacral, this being preserved in the adductor magnus of mammals.

The history of the area of origin has been the same as that of the flexors; with the loss of the pubo-ischiadic ligament in mammals, the adductors are found, as expected, along the ventral surface internal to the flexors.

The insertion in primitive fossil types may be laid out as the surface antero-dorsal to the ventral femoral ridge and coccygeo-femoralis tendon, bounded proximally by the pubo-ischio-femoralis internus, and by that muscle antero-dorsally until replaced in reptiles by the femoro-tibialis. On the opposite side of the ridge is found the ilio-femoralis. These relations are preserved through into the Mammalia, where the adductors are found located between pectineus and iliacus proximally and internally, vastus interno-dorsally, and the ridge running down from the gluteal insertion posteriorly.

6.—Pubo-ischio-femoralis Externus (Obturator Externus and Quadratus Femoris)

Plates XLIII; XLIV, origins; XLVI, Figure 6, insertions

Gregory and Camp (1918, pp. 491–493) do not differentiate this muscle from the adductor. It is a stout, short muscle from most of the

pubo-ischiadic plate, or the replacing fenestra, to the proximal ventral surface of the femur. The innervation, as expected, is almost always double, sacral and obturator. The insertion in all the Permian fossil forms (essentially similar to the more generalized reptiles and urodeles) is into the fossa between the two proximal branches of the ventral femoral ridge and on to the internal trochanter which terminates the inner branch. In the mammalian series the insertion on the inner (minor) trochanter has been lost, but the fossa is retained as the intertrochanteric fossa, into which the obturator externus inserts. The quadratus femoris inserts into the distal boundary of the fossa. This latter muscle, from this much more distal insertion, appears not to be a part of the ischio-trochantericus or obturator internus, as has sometimes been stated (Gregory and Camp, 1918, p. 493). It will be noted that this split into obturator externus and quadratus femoris has been along the division between the two innervations, the obturator externus being purely obturator, the quadratus femoris purely sacral.

7.—Caudal Muscles to the Limb

Plates XLI, XLII; XLVI, Figure 6, femoral insertions

Coccygeo-femoralis Brevis or Caudi-ilio-femoralis (Pyriformis), and Coccygeo-femoralis longus, Caudi-femoralis or Caudi-pubo-ischio-tibialis. Originally two muscles, both arising ventrally from the anterior caudal vertebræ and running out under the ilio-ischiadic ligament to the limb. The more dorsal of the two (brevis) inserts by a tendon into the femur part way down the shaft, reaching the bone between ilio-femoralis and adductors. The longer, ventral to this, either inserts into the flexor mass, as in urodeles, or has a tendon of its own in reptiles, this inserting with the short muscle into the femur and sending a branch out to accompany the flexors to the lower leg or the end of the femur. That this separation from the flexors is a secondary one is rendered more probable from the discovery by Noble (1922) of a typical caudi-pubo-ischio-tibialis in primitive frogs.

The insertion of the coccygeo-femoral tendon is one of the landmarks of the primitive femur, being a roughened and often much elevated area at the point where the two proximal branches of the adductor ridge separate. It is usually less prominent in short-tailed forms, as would be expected. This point is comparable with the crocodile fourth trochanter.

The fate of these muscles in the mammalian series is doubtful. I have never seen a therapsid humerus that clearly indicated the femoral insertion. Their reduction is, of course, expected with the functional

reduction of the tail in the mammalian line. The coccygeo-femoralis brevis is probably represented by the mammalian pyriformis (Gregory and Camp, 1918, p. 497), which has been carried up to the greater trochanter in the rearrangement of the gluteals; the longus by slips from the tail to join or accompany the semitendinosus or biceps in various mammals (such as the cruro-coccygeus of the opossum).

8.—Lower Leg: Extensors

The reptilian condition is that of three groups as follows. (*a*) Fibular, usually a peronæus longus from the external margin of the femur and the head of the fibula, and a peronæus brevis from the shaft of the fibula, and both running down to metatarsal 5 and the lower surface of the foot. Both are dorsal (external) to the ilio-fibular insertion. (*b*) An extensor digitorum communis longus, from the end of the external condyle, and sending tendons to the toes. (*c*) Tibialis anticus, from the outer surface of the tibia, dorsal and external to the pubo-ischio-tibial insertion, to metatarsal 1. In addition, there is an extensor hallucis running diagonally across from the lower end of the fibula. As far as can be determined, the relations were similar in the American Permian forms. There are roughened surfaces for the common extensor and peroneus longus on the external condyle of the femur. The outer surface of the fibula was undoubtedly for the peronaeal origins, except for a roughened area near the head for the ilio-fibularis. There is no indication of an origin of tibial extensors from the internal condyle; a small tuberosity always found here was undoubtedly for the medial ligament to the tibia. The tibialis anticus occupied a somewhat uncertain area bounded externally by the roughened line for the interosseous ligament, internally by the ridge for the pubo-ischio-tibialis and part of the flexor tibialis internus, and by the ridge for the triceps (quadriceps) insertion.

It will be noted that the urodele extensors differ in several particulars from the conditions in higher forms. The tibial mass originates from the femur, internal to the course of the triceps; part of tibial and fibular masses insert on those bones; there are no origins there. The triceps, although breaking through the tibial mass to reach the tibia, is mostly continuous with the fascia covering these muscles, the break leaving variable slips external to it. The fossils give, as far as I have seen, no suggestion as to the relations of this urodele type to that of higher forms.

Between the reptilian and mammalian conditions, there is little change. Many forms tend to lose the femoral heads; the peronaeal group becomes differentiated.

9.—Lower Leg: Flexors

For our purposes, the varied development of the end tendons of this group do not come into consideration.

The general reptilian condition is that of three superimposed layers. (*a*) Gastrocnemius, in two parts, one from the external condyle of the femur, the other from the internal condyle, the head of the tibia (ventrally) or both; the two uniting to form the superficial layer of the sole. (*b*) Flexor digitorum communis longus, from the external condyle of the femur, and from most of the length of the fibula, usually with several heads. This lies beneath the gastrocnemius; both may be united with flexor tibialis externus. (*c*) A deeper layer, lying close to the interosseous ligament, with typically three parts: (1) tibialis posticus, of *Sphenodon* and turtles, from the fibula diagonally down towards the first toe; (2) a popliteal muscle from the head of the fibula to the back of the tibia; and (3) an interosseous cruris lower down between fibula and tibia.

In urodeles *a* and *b* are apparently fused. The last group is similar but there is no popliteal, except possibly a small muscle from femur to tibia mentioned by Wilder. In urodeles there are no origins from the tibia or tibial condyle of the femur, nor from this condyle of the femur in *Sphenodon* or the crocodile.

There is little fossil evidence as to the detailed structure of these muscles.

There are few important changes in mammals, except in connection with the end tendons.

10.—Groupng of Hind Limb Musculature

The grouping of the hind limb musculature in primitive dorsal and ventral masses (abductor and adductor groups of the fish) is a more simple problem than that presented in the fore limb as, with few exceptions, the muscles may be arranged in two groups, dorsal and ventral (each subdivided into more superficial and deeper layers on the proximal segment) and distally the extensors and flexors of the lower leg and foot, each group having double innervations suggesting its primitive metameric condition (Fig. 1).

a.—Primitive Dorsal Group: ambiens, ilio-tibialis, femoro-tibialis, ilio-fibularis, pubo-ischio-femoralis internus, ilio-femoralis, ischio-trochantericus, and lower leg extensors (in mammals, sartorius, rectus femoris, vasti, biceps, psoas, iliacus, glutei, gemelli, obturator internus, and lower leg extensors).

b.—Primitive Ventral Group: pubo-tibialis, pubo-ischio-tibialis, flexor tibialis internus, and externus or ischio-flexorius, adductor, pubo-ischio-femoralis externus (in mammals, gracilis, semitendinosus, semimembranosus, adductors, obturator externus, quadratus femoris and lower leg flexors). With these the two coccygeo-femoral muscles (pyriformis, cruro-coccygeus, etc.) may possibly be associated.

HIND LIMB, BONY ELEMENTS

1.—Pelvis

Plates XLIV, XLV

This uniformly consists of three bones of unquestioned homology, the dorsal ilium, the anterior ventral pubis, and the posterior ventral ischium, the three usually meeting at the acetabulum.

Little is known concerning the evolution of the girdle from the fish condition. The fish girdle is usually a simple plate from which muscles arise on both sides, and which seems to correspond with the continuous pubo-ischiadic plate of primitive tetrapods. Except in dipnoans, there is no development of an iliac process.

We shall consider (*a*) the iliac blade, (*b*) the dorsal or inner surface of the pubo-ischium, (*c*) the pubo-ischiadic plate, and (*d*) the acetabulum.

a.—Ilium. Need for support in terrestrial life has modified the pelvis even more than the shoulder. We have previously called attention to the fact that in the posterior extremity a fixed relation to the body does not entail the disadvantages that it had in the fore limb; and it is the fixed position that has been attained by the growth of the ilium upward, interrupting the lateral musculature.

It will thus be seen that the ilium is primarily for support, connecting the pelvis and limb with modified sacral ribs (or rib) and that the appendicular muscular relation, so prominent in later forms, has been a secondary development. Existing urodeles and fossil stegocephs bear this out. In urodeles, as in *Eryops*, the limb musculature has little to do with the ilium, being confined to a small area just above the acetabulum. The muscles (ilio-tibialis, ilio-fibularis, ilio-femoralis) which originate from it are of small extent in primitive forms; all three show some tendency to slip around to the inside of the bone; the ilio-femoralis is hard to delimit from the pubo-ischio-femoralis internus in some urodeles. It seems probable that all three are really muscles from the inside of the girdle which the ilium has "picked up" in its development. The rest of the stegocephalian blade is concerned with axial muscles and is usually rather long and narrow.

As we have mentioned in the discussion of the axial muscles, the outer surface of the amphibian ilium is homologous not only with the outer side of the higher forms but also with the inner dorsal part above the sacral ribs. This is undoubtedly due to the great growth in size of the part of the pelvis connected with appendicular muscles, and especially due to the increase of the muscles used to extend the limb and draw back the femur. We have shown that this upward growth has folded over the upper end of the ilium, and have mentioned a series of forms showing this.

The posterior dorsal portion of the ilium is often expanded more or less into a posteriorly directed process, which seems to be correlated with the length of the tail and the consequent development of the tail extensors. Thus in *Eryops*, where the tail was short, there is practically no backward extension; in *Diadectes* it is slight; while the longer tailed *Limnoscelis* has a longer backward expansion. In the pelycosaurs, *Dimetrodon* has only a short backward extension as compared with the longer tailed *Ophiacodon*.

Cricotus has a very long posterior process, which at first seems remarkable in the fact that this does not spring from the upper end of the bone but from near the acetabulum. This is easily explained; in *Cricotus* this position is at the posterior end of the transverse iliac line previously referred to: hence this posterior process is really the homologue of that seen in reptiles, which comes off from the posterior end of this same line, which becomes the dorsal end of the ilium. *Cricotus*, it will be noted, has a well-developed tail.

In reptiles, the whole outer surface is for appendicular muscles, the axial muscles being confined to the borders and the new dorsal internal surface; the primitive pelycosaurian and captorhinomorph ilium is not unlike that of the Lacertilia.

In the change to the mammals, the main factors are as follows. (1) Transfer of ilio-fibularis, which travels back down the ilio- (sacro-) ischiadic ligament to become the biceps. (2) Great growth of the ilio-femoralis, which has conditioned a great upward and forward growth of the ilium, and changed the relations of the ilio-tibialis. This is seen under way in the therapsids. There has been a secondary reduction of the iliac surface at some point below the monotremes, probably by such an emargination as is seen in *Lystrosaurus*. (3) The pubo-ischio-femoralis internus has invaded the ilium, coming up forward to form the lower external surface of the trihedral type and then subsiding into the external part of the gluteal surface; and a possible incipient stage may be seen in some dicynodonts, with the lower anterior margin of the ilium somewhat broadened.

There has been an increasingly close association of the ilium with the backbone through the sacral ribs, of which there was probably but one originally. This union in *Eryops* was probably not close, the single sacral being but slightly modified and expanded for its articulation with the pelvis, which covers most of the inside of the iliac blade. The *Cricotus* ilium seems to indicate a similar relation.

The change to the Reptilia usually makes the number of ribs two instead of one, although Williston (1916, pp. 202, 216, etc.) has noted exceptional Amphibia with two and exceptional reptiles with but one. The number and closeness of articulation increases in mammals. This relationship seems highly adaptive.

The principal evolutionary changes in the ilium are thus seen to be (1) development of primitive supporting function by increase of sacral connections; (2) development of dorsal limb musculature and crowding out of axial elements externally; (3) anterior expansion in mammalian ancestry correlated with gluteal growth; and (4) invasion in this line by the iliacus from the original pubo-ischio-femoralis below.

b.—Dorsal (Internal) Surface of the Pubo-ischium. As suggested above, we may believe this to have been the primitive place of origin of all the dorsal muscles. The ilium by its development has broken the dorsal series so that, with the partial transfer of muscles to that element, we find merely (1) pubo-ischio-femoralis internus from the anterior part and (2) ischio-trochantericus (ischio-femoralis posterior) from the posterior part of this surface.

We have noted the well-marked shelf for the pubo-ischio-femoralis internus in the primitive Amphibia and the gradual inturning of this in reptiles. Near the posterior border of this shelf is found the internal opening of the probably primitive obturator foramen. Then, posteriorly, there is a smooth surface, probably without muscular relations, between the two ilia, and, still more posteriorly, behind a ridge for the caudal flexors, a fan-shaped surface on the upper side of the ischium for the ischio-trochantericus, running back to the tuber ischii and the posterior end of the symphysis. Anteriorly and posteriorly there are means of escape for these muscles on to the limb underneath the ilio-pubic and ilio-ischiadic ligaments. There has been little variation in the ischio-trochanteric surface; even in most mammals, the muscle is of only small extent. In reptiles, the pubo-ischio-femoralis internus has spread widely over the inner surface of the pelvis, in a further development of the old type of locomotion, while in the mammal the muscle has abandoned this area and migrated up (except for pectineus) on to the ilium in response to a different type of movement.

The symphysis seems to have been inversely proportionate in its strength to that of the sacral articulations. For example, in *Eryops*, with a weak sacrum, the symphysis is extremely thick; in the higher forms, with a better sacrum, the thickness is reduced, although the old pattern of *Eryops*, which has the thickness reach a maximum at the posterior edge of the pubis, is still seen especially in *Diadectes* and *Limnoscelis*. In later forms, the symphysis is shorter and may be reduced to two connections, anterior and posterior, as in lizards and *Sphenodon*, or be greatly reduced in length, as in mammals. (The foramina will be discussed under the next head.)

c.—Pubo-ischiadic Plate. This is highly comparable in primitive position and function to the coracoid plate. In the primitive forms it is a broad expanse on the outer, lower side of the pubis and ischium, beneath the acetabulum. Most of its surface gives origin to the pubo-ischio-femoralis externus. From the dorsal border, behind the acetabulum, is a ridge separating the plate from the internal surface and often giving origin to fibers probably homologous with the mammalian quadratus and gemelli. This terminates at a corner marking the tuber ischii, from which the edge of the bone turns inward to the symphysis. Anteriorly, from the rugosity just anterior to the acetabulum whence the ambiens and pubo-tibialis originate, there is a ridge, usually turned strongly outward which separates the plate from the anterior part of the dorsal surface. This ridge terminates anteriorly at the most anterior and external corner of the pubis, representing the pubic tubercle (especially well developed in *Ophiacodon*, Case and Williston, 1913, p. 53) and the ventral insertion of the ilio-pubic ligament. The surface running in from the tubercle to the symphysis usually has indications of a cartilagenous extension. Medially, the symphysis is primitively continuous throughout the whole length of the plate; from the symphysis, the posterior border of the ischium to the tuber, and the pubic tubercle, originate the adductors and the flexors, directly or, probably generally, by means of the pubo-ischiadic ligament. The dorsally running ligaments attach anteriorly and posteriorly, to the pubic tubercle and tuber ischii. On the edge of the ischium behind the tuber are the attachments of the ischio-caudalis and cloacal muscles; anteriorly the axial musculature is attached to the end of the pubis, often running down over the symphysis. The opening for the obturator foramen is found in the pubis, beneath the anterior end of the acetabulum.

This primitive type of plate is well represented in *Eryops*, and is not markedly changed in the Permian cotylosaurs and pelycosaurs. The

two halves of the pelvis are more widely separated, and the plates are more nearly horizontal in position.

The modifications in the plate which lead to the characteristic "archosaurian" type do not concern us here but may easily be derived from this, such forms as *Euparkeria* showing transitional stages. In the more typical reptiles, lizards and *Sphenodon*, a large foramen is developed, as has also been done in mammals, into the origin of which we might inquire.

In the reptilian cordiforme or thyroid fenestra, the opening is a circular one in the middle of the plate, separating the pubis and ischium, except in the acetabular region; below, the two bones are usually connected by a ligament; the foramen is covered by a membrane. In the lizard, as contrasted with mammals, the obturator nerve is not included in the opening, but has its own passage through the pubis.

Williston (1911, p. 105, etc.) has suggested, because of the incomplete ossification of the ventral connection between pubis and ischium in certain pelycosaurs, that the formation of the reptilian fenestra may have taken place by the formation of an opening here between the four bones of the two sides; that the opening then extended dorsally on either side to its modern position; and that later there was a secondary cartilagenous union across the ventral gap. Both shape and function of the fenestra argue against this.

The function of both reptilian and mammalian fenestræ (Gregory and Camp, 1918, p. 524), besides lightening the girdle, is to give an open area instead of bone for the great muscular origin of the pubo-ischio-femoralis externus (obturator externus), analogous to the temporal and coracoid fenestræ. No such function would be subserved by an incipient opening of the character suggested by Williston. Such an opening as is seen in these pelycosaurs is a notch in shape and would have to undergo radical changes in order to assume a closed circular form, changes for which we have no evidence nor find apparent reason. The "fenestra" seems to be merely a case of incomplete or delayed ossification, as is found in other parts of the skeleton of the same animals (as in the late ossification of the *Ophiacodon* posterior coracoid). A similar notch is found in some dicynodonts (Broili, 1908, p. 8), which is certainly not an incipient fenestra, as this is already formed in a more dorsal position. It seems more probable that the reptilian fenestra is a parallel to that of the mammals, a fenestration for the obturator externus.

The lower therapsids have no fenestra; in the dicynodonts it is merely an enlargement of the obturator foramen; in *Cynognathus*, it is a

somewhat larger opening, but still mostly confined to the pubis; considerable further growth has been necessary for it to reach its full mammalian development. Here it will be noted that the obturator has been included from the beginning and apparently forms the basis for the opening.

Apart from the fenestra, the typical reptilian plate is much like the primitive one. The mammalian type can be readily derived from this, the other major change having to do with a great elongation anteriorly, followed by a secondary reduction. The pubis is uniformly reduced in antero-posterior extent; but "marsupial bones," still present in monotremes and marsupials, have been formed in advance of the pubis, mostly in relation to the axial musculature. At first these were probably merely undifferentiated cartilagenous extensions of the pubis, as suggested by the fact that in monotremes the gracilis continues indifferently on to them from that element. The anterior contour of the pubis in *Cynognathus*, from "pectineal process" to symphysis, suggests the presence of cartilages. With this development, the old pubo-ischiadic ligament has apparently been lost.

Although short, the pubis is still strongly turned out dorsally in *Moschops* and *Cynognathus;* posteriorly there is a suggestion of a slight differentiation of a posterior region of the plate for a quadratus femoris. The gemellus surface is distinct.

Changes in the plate from the primitive condition are thus seen to be (1) a more horizontal position of the plate, (2) opening of a fenestra in at least two parallel lines, and (3) changes in shape of pubis, with addition and subsequent loss of marsupial bones in the evolution of the mammals.

d.—Acetabulum. The history of this is comparatively simple as compared with the glenoid. There is never any "screw"; it is a cup from the first. This is undoubtedly correlated with the facts that (1) there is little need for support, the whole action of the limb being for propulsion, and (2) the comparatively fixed condition of the lower limb, with little power of pronation or supination, has rendered it necessary that the femur rotate to preserve its relations to these bones.

The acetabulum is relatively constant throughout the series, as a cup formed from the three bones of the pelvis. Primitively the pubis and ischiadic borders are raised considerably above the surface, indicating that the femur was normally elevated distally. In *Eryops*, the pubic process is very prominent, indicating that here the femur was probably turned somewhat back in its middle position; in pelycosaurs, the pubis

is reduced here, the femur probably looking out and somewhat forward. In the mammalian line, where the head was turned towards the side of the femur, the acetabulum is large and looks directly outward.

A constant feature is the presence of a prominent wedge above the acetabulum, merging gradually into the general surface of the bone anteriorly, but posteriorly dropping back sharply as a distinct supra-acetabular notch. This is found practically the same in almost every form examined, from *Eryops* to the highest therapsids. As suggested by Broili, who first noticed it in dicynodonts (1908, p. 3), it indicates the position of a ligament similar to that found in the cotyloid notch of the ischium of mammals; the changed position of the mammalian femur would account for a shifting ventrally of the notch.

2.—Femur

Plate XLVI; Figure 6

The femur may be considered in its two aspects of a supporting structure and of an object for muscular origin and insertion.

As has been mentioned, the primitive femur did not have to contend with the complicating necessity for support that the primitive humerus had; its function was merely that of giving a forward push to the body, and in its simplest form was a straight rod running from a terminal head in the acetabulum to distal ventral condyles for the lower leg bones. As Williston has noted, it is usually a longer although more slender element than the humerus. Its main movement is one down and back from an anterior and dorsal position, coupled with rotation (clockwise as seen in the right leg from the side view). This movement, as far as the femur is concerned, is principally accomplished by: (1) the depression caused by the pubo-ischio-femoralis externus; (2) a backward pull, by the posterior part of that muscle and the coccygeo-femoralis muscles; and (3) rotation, caused somewhat by these two and partly by the opposed ilio-femoralis and pubo-ischio-femoralis (adductor). It is these muscles that primitively give the main characters to the bone; they are concerned with the ventral and lateral surfaces.

We may best understand the construction of the primitive femur by a description of such a form as *Eryops*. Seen ventrally, the main characters are as follows. (1) A ridge, sometimes termed the "adductor ridge," running distally down the shaft, usually terminating near the external condyle. Proximally to the middle of the shaft, the ridge divides like the letter Y into (2) a posterior and (3) an anterior branch, between which is (4) a large ventral fossa. Near the point of union of the two

branches is (5) a large roughened area. The insertion of the adductors (pubo-ischio-femoralis) probably lay on the anterior side of the "adductor ridge"; that of the ilio-femoralis adjoined on the posterior side. The area at the fork of the ridges was for the insertion of the coccygeo-femoralis tendon. Between the branches of the ridge was part of the insertion of the pubo-ischio-femoralis externus, and the remainder of the muscle inserted on the end of the anterior limiting ridge, or internal trochanter, which drops suddenly to the level of the bone. Above the posterior limiting ridge, the ilio-femoralis insertion probably continued nearly to the head; above the anterior limiting ridge, the pubo-ischio-femoralis internus insertion ran down to meet the adductor, from which it is not clearly separable. This agrees well with the lacertilian condition.

The dorsal side of the femur of such a form as *Eryops* presents few landmarks; as a point of insertion, it functions only for pubo-ischio-femoralis internus. I have previously suggested that the slenderness of the amphibian shaft is due to the absence, or presence merely below a limiting ridge, of the femoro-tibialis, and that the pubo-ischio-femoralis internus covered the dorsal surface rather loosely, being only apparent at a posterior rugosity near the head.

Distally, there is a double condyle for the two articular portions of the head of the tibia; an accessory condyle on the outer side for the fibula; a small internal eminence, probably for the medial ligament; a roughened surface and pit on the outer condyle for the extensor digitorum communis and peroneus; below, an area for the external head of the lower leg flexors.

There is some variation in the Stegocephalia; the posterior limiting ridge is frequently reduced, leaving one continuous ridge from the internal trochanter diagonally down the limb to the external condyle. In one form (whether amphibian or reptile is uncertain) found by Case (1915, Pl. XXIII, figs. 5 and 6) the area for the coccygeo-femoralis is an enormous development projecting out backwardly for a distance equal to half the length of the femur.

In the most primitive cotylosaurs (*Seymouria*, *Diadectes*, *Limnoscelis*) there is essentially the same plan on the under side; dorsally, the only change is that the median portion is expanded, apparently because of the intrusion of the femoro-tibialis, giving the bone a more rounded form, in general, than in the Amphibia and thus reducing the apparent size of the ventral ridge system, which is still prominent.

There is in the higher cotylosaurs and pareiasaurs a parallel to the Amphibia in the reduction of the posterior limiting ridge ventrally, and

the height of the ridge is somewhat reduced. The poliosaurs are similar. On the other hand, the femora of *Edaphosaurus* (and *Ophiacodon*) are still rather primitive and the ridges are well developed. In *Dimetrodon*, the ridges are much reduced, there being little elevation at the pronounced rugosity for the coccygeo-femoralis insertion.

Such a form as the femur of the lizard can be easily derived from the Permian type (Fig. 6). The anterior limiting ridge is the well-developed inner trochanter (for most of the pubo-ischio-femoralis externus); some of this muscle still inserts into the neighboring fossa, less pronounced; the relations of adductors and ilio-femoralis to the adductor ridge is represented by their relations to the so-called "linea aspera." The coccygeo-femoralis still inserts in a similar position. This, it will be noted, is the same as the "fourth trochanter" of crocodiles, etc., and this name might well be applied to this whole series of coccygeo-femoralis insertions in all primitive forms. Von Huene (1911, pp. 55–56) has claimed that the internal and fourth trochanters have the same origin; this is, of course, incorrect but explicable, because of the once continuous ridge between these two points noted by Gregory and Camp (1918, p. 534).

The transition to the mammalian type has been a puzzle. The monotreme femur and those of the therapsids help to clear up the matter, but it is impossible to speak with too great certainty because of the usually poor condition of the surface of African fossils.

The evolution of the head is simple. As seen in therapsids, there is merely a flexure of the old head upon the shaft, so as to allow the femur to be directed forward and have an up and down movement; this has been paralleled in some reptilia. The primitive therapsid head was large, and flattened antero-posteriorly, thus necessitating the large acetabulum to which reference has been made.

But the muscular insertions at first appear strangely different. The therapsids give a clue to this change. There has been a flattening of the femur in the horizontal plane, which is preserved in the monotremes; the ventral ridge and posterior proximal ridge have become the posterior edge of the therapsid and monotreme femur. This is no great change, as the position of the ridge in the natural primitive pose was rather to the back as well as the ventral side, and a similar tendency is shown in *Propappus* and *Ophiacodon*, etc. The old insertion of the ilio-femoralis was at the posterior dorsal side of this ridge; it now inserts, as the glutei, in this posterior edge of the femur, sometimes extending well down the shaft as the lateral lip of the linea aspera. The more proximal insertion was outside the posterior limiting ridge; it is from this surface that the

greater trochanter has arisen and thus occupies the position of the old ridge, although not its exact function. Primitively it was for the most part merely a boundary for the fossa beneath.

With the loss of any extensive area of insertion of the gluteals well down the shaft, the adductors have come to meet the vastus on the posterior border of the femur; it is the boundary between these two muscles, the lateral lip of the linea aspera, extending proximally up to the greater trochanter, which is the modern representative of the old adductor ridge. The vasti still occupy the dorsal surface and now meet the adductors on the anterior (internal) side of the femur as well. It is here that the median lip of the linea aspera is found; it is thus a new formation, and has no reptilian predecessor. The pubo-ischio-femoralis internus (iliacus, psoas, pectineus) has lost its old dorsal insertion and has merely retained the anterior portion of the old insertion, which it will be noted was just above the anterior limiting ridge or internal trochanter. It is in this position, anterior (internal) to and above the ventral fossa, that we find the lesser trochanter, which gives insertion to iliacus and psoas major (the pectineus insertion continuing down the shaft). This trochanter is in the position of the old internal trochanter (anterior limiting ridge) of the primitive forms, but it is entirely different in function; the former offered an insertion for the pubo-ischio-femoralis externus; the new lesser trochanter carries the representatives of the pubo-ischio-femoralis internus. But the ridge on the under side of many therapsid humeri (Gregory and Camp, 1918, p. 530) seems homologous in position with both mammalian pectineal line and lesser trochanter on the one hand and on the other with the old internal proximal ridge (or internal trochanter). These are now not connected with the posterior proximal ridge and stem of the Y-system, which have become, respectively, the greater trochanter and lateral lip of the linea aspera.

The fossa, for pubo-ischio-femoralis externus, is still present and functional; its boundary, the inter-trochanteric ridge, gives insertion to a portion of this muscle's representatives, the quadratus femoris.

The growth of the greater trochanter has pushed the internal obturator down into the fossa. It is on the greater trochanter in monotremes.

The coccygeo-femoralis insertion is not recognizable, as expected, in any of the mammalian series and, as indicated from the position of the pyriformis, has been carried up on to the greater trochanter.

Thus we see in the mammals the retention of the old ventral fossa, a partial homology of the trochanters with the old limiting ridges and

internal trochanter, and reduction of the adductor ridge and "fourth trochanter." It will be noted that in this process, apparently of flattening and secondary rounding of the femur, there has resulted a general rotation of points of insertion, downward anteriorly and backward ventrally.

3.—Tibia and Fibula

There are few points of interest obtainable in regard to the history of the tibia and fibula from the fossil forms. It is probable that the two were subequal primitively or, as has been advanced, that the fibula was the main axis of the primitive limb. It is comparatively well-developed in Amphibia. But the position of the limb has caused the tibia to be the main bearer of the weight and the main point of insertion of muscles coming from the more proximal part of the leg. The fibula is reduced in higher forms, and functions mainly as a point of origin for muscles running down the leg.

As far back as the history can be followed, the tibia has two points of articulation for the two condyles of the femur, the two partially separated; on its anterior surface is a ridge proximally for the insertion of the triceps tendon. Internally and externally are found longitudinal markings and ridges separating flexor and extensor surfaces. The fibula, usually attached at the side of the external condyle, is usually a flattened bone, with the anterior or internal edge concave; the two opposing surfaces are universally filled by the areas of origin of the flexor and extensor muscles of the lower leg. In Permian forms a proximal rugosity for ilio-fibularis is found near the head.

LOCOMOTOR ADAPTATIONS AND COMPARISON OF TYPES

1.—Diadectes

We may best start with a consideration of this form as representative of the most primitive reptilian condition of which we have knowledge. While specialized in other respects, *Diadectes* is close to *Seymouria* and *Limnoscelis* in girdle and limb structure.

The general impression given by *Diadectes* is that of an animal with short but stout limbs, capable of slow but rather powerful movement.

In the fore limb, the principal motions for the advance of the body consisted of a backward and downward movement of the humerus, combined with rotation, and flexion of the forearm. The coraco-brachialis maintained the level of the humerus and pulled backward. The back-

ward pull was assisted by the latissimus and sub-coraco-scapularis above. Rotation was accomplished by the coraco-brachialis longus. The flexion of the fore arm was accomplished by the biceps and brachialis, assisted by the pronator and ulnar flexor. The opposite motion of the arm, up and foward and an opposite rotation, was accomplished by the deltoid, scapulo-humeralis anterior and supracoracoideus, triceps, extensors of the fore arm, and supinator. The body was carried sling-wise by a strong series of levator and serratus muscles.

In the hind limb, the principal motion was a down and backward pull of the femur, accompanied by rotation of the femur (clockwise in the right limb) and extension of the lower leg. The pubo-ischio-femoralis externus and adductor draw the femur down; the caudi-femoral muscles, assisted by the posterior part of the first named muscle, pull the femur back; rotation is accomplished by the ilio-femoralis and adductor; extension of the lower limb by the triceps and short extensors of the lower leg, if present. The opposite motion is caused by the pubo-ischio-femoralis internus, ischio-trochantericus, long flexors, and lower leg flexors.

In this connection, we may note the following features of the skeleton. A fairly tall scapular blade, and large uncinate processes on the under-lying ribs, denoting a strong serratus anterior-levator series. A capping cleithrum (not true of other primitive reptiles). Large supra-glenoid buttress with foramen. Well-developed clavicles and inter-clavicle (the stem of the latter moderately long). A large coracoid plate (apparently one element, two in *Limnoscelis*). Glenoid foramen. Primitive type of glenoid. Humerus short, no shaft, of tetrahedral type, with large muscular processes. Entepicondylar foramen. Very large entepicondyle. Large supinator crest, not approaching the ectepicondyle. The latter large and overhanging.

Iliac surface fairly large, axial muscles restricted to upper borders and shelf at top. A sharply marked anterior surface on the pubis for the pubo-ischio-femoralis internus, containing the internal opening of the obturator foramen. A thick pubic symphysis. A small surface dorsally on the ischium for the ischio-trochantericus. A large pubo-ischiadic plate, with the obturator foramen, but no fenestra. A strong, short femur. The Y-shaped system of ridges well developed, especially the caudi-femoralis insertion, the anterior (internal) branch of the Y being continuous with the stem. A large dorsal surface for the femoro-tibialis.

2.—Comparison with Amphibian Types

The type of motion and the structural plan of *Diadectes* are remarkably similar to the general stegocephalian type, such as the well-known *Eryops*. The only differences of note are as follows. *Eryops* has a taller scapula, but this is probably related to its extremely large head; many other Rachitomi have shorter scapulæ. The coracoid plate is smaller, probably denoting a smaller backward movement of the humerus. There is no trace of division of the primary girdle into elements. The interclavicle is shorter, indicating a weaker pectoralis. There is no entepicondylar foramen, and a smaller entepicondyle, indicating weaker flexors. The sacral connections are looser. There is a smaller appendicular and larger axial surface on the ilium, without formation of a shelf. The pubo-ischio-femoralis internus origin is very strongly developed. There is a very thick pubic symphysis, probably related to the weaker sacrum. A small femoro-tibialis, indicating little extension of the lower leg.

Thus *Eryops* and other Rachitomi are seen to be an essentially similar type, but more primitive in certain respects. There is no bar to considering an animal with such a type of locomotor apparatus as almost directly ancestral to the primitive reptiles, as far as we know them.

The microsaurs are a poorly understood group which probably contains several distinct lines. The presence of the entepicondylar foramen in *Diplocaulus* has been noted, as has the *Eryops*-like femur of *Ichthyacanthus* and the T-shaped cleithrum of some forms. But, as a whole, the microsaurs are too specialized, too degenerate in limb structure, and too poorly known to make comparison profitable.

Back of the primitive Stegocephalia, and in the province of the embolomerous forms whose primitive characters have been so much emphasized by Watson, the path is none too clear; there is not one type of which the limb structure is known in any detail. Primitive features, leading back toward the fish, can, however, be identified here and there. The widely opened supraglenoid foramen of lower forms, as the girdle assigned to *Cricotus* by Case (1915, p. 163), suggests the mesocoracoid region of the fish. The posterior prolongation of the ilium, correlated with the long tail, cannot be safely set down as a primitive character. The problem as to whether the flattened trihedral type of humerus of *Cricotus* is primitive has been discussed.

3.—Higher Cotylosaurs, Captorhinomorpha

Limnoscelis cannot be grouped here (as Watson would do on the basis of the skull) in regard to limb structure. The type is generally

primitive, but with more of a shaft to the limb bones. The general type of motion is that of the lower cotylosaurs. The cleithrum is absent or very small. There are two coracoids (also true of *Limnoscelis*). There is no ectepicondylar foramen, but the supinator crest is close to the ectepicondyle. There is a fairly well distinguishable pubo-ischio-femoralis internus surface on the pubis. The posterior branch and main body of the Y ridges of the femur are reduced, the anterior branch still being a continuation of the rugosity marking the main body. The caudi-femoral insertion is reduced.

The in-turning of the axial portion of the ilium has been accomplished, in marked contrast to some of the supposedly higher pelycosaurs.

There do not seem any obstacles to a derivation of these forms from the lower types of cotylosaur, very possibly through some such a form as *Limnoscelis*.

4.—Pareiasauria

In a great number of respects this Old World group differs radically from both the lower cotylosaurs, with which the latest classifications would include them (Watson, 1917), and from the higher Captorhinomorpha as well. In almost every case the differences are characters which are found in therapsids. The cleithrum is present. There are two coracoids, as true of many American cotylosaurs, but the anterior one does not enter the glenoid. An acromion is present (found elsewhere only in the higher therapsids). No supraglenoid buttress or foramen has been described. The primitive type of glenoid is partially or entirely lost. The coracoid plate is not developed posteriorly. No glenoid foramen has been described (also absent in Captorhinomorpha). The humerus, while short and massive, is strikingly different from the primitive tetrahedral type. Some forms very probably possessed an ectepicondylar foramen. The proximal part of the median humeral surface for the triceps is greatly reduced. The entepicondylar foramen is small and is turned down on the back surface. There is a long delto-pectoral crest and a large brachialis surface. The iliac blade has completed the turning in of its axial surface (also true of Captorhinomorpha). The separate surface for the pubo-ischio-femoralis internus is not well developed. The ilium is extended anteriorly. The Y-system of femoral ridges is reduced, except for the anterior branch, and the coccygeo-femoral insertion is also reduced (much as in Captorhinomorpha); the posterior edge of the femur, leading distally from the posterior branch of the Y, is emphasized.

Almost all of the characters are highly characteristic of therapsids and are in sharp contrast with the typical cotylosaurs and with the pelycosaurs. The anterior coracoid enters the glenoid in the latter groups. The supraglenoid buttress is characteristic of all pelycosaurs, even, and the supraglenoid foramen is absent only in *Casea*. The primitive glenoid is otherwise universal. The humerus is quite unlike that of any other cotylosaur or pelycosaur. The ectepicondylar foramen (if present) is not found in other cotylosaurs or pelycosaurs, except for *Edaphosaurus*. The median tricipital surface is well developed in the American cotylosaurs and pelycosaurs. The form of the entepicondylar foramen is in marked contrast. The iliac blade is never developed anteriorly (except in *Casea*) in the groups mentioned and is still incompletely evolved in some pelycosaurs. The short pubis contrasts with the usual long pubis of the American groups. The femoral ridges are usually better developed and the posterior edge of the femur is never pronounced in American forms, a somewhat similar appearance in *Ophiacodon* being merely the stem of the Y-system.

It has been said that the therapsid-like characters of this group are only the results of parallelism or convergence; but, even with our present knowledge of these phenomena, it seems impossible that the pareiasaurs could have made this amount of positive advance over the primitive cotylosaurs and not be at all connected with the therapsids. Considering the few faunas of Carboniferous and early Permian age of which we have knowledge, it would seem not improbable that the pareiasaurs may be a specialized offshoot of a cotylosaurian group from which the therapsids have sprung, and that these resemblances are due to a real, although distant, relationship.

5.—Pelycosauria

The general conception of the pelycosaurs, in a broad sense, is that of a group of reptiles of a somewhat higher grade of organization than the cotylosaurs and with the one common feature of a lateral temporal opening. Other than this, there seems to be little to bind the group together; common features are mostly inheritances from a cotylosaurian ancestry. In general, the limbs are of cotylosaurian type, and functionally about on a level with those of the Captorhinomorpha. We may distinguish at least five groups, each with characteristic limb features.

a.—Caseidæ. The cleithrum is lost. There is no supraglenoid foramen. Probably two coracoids. No ectepicondylar foramen. The iliac blade completely developed, and extended somewhat forward.

Posterior branch of femoral Y and caudi-femoralis insertion reduced, anterior branch leading to reduced stem.

b.—Ophiacodontidæ. Possibly a cleithrum. Supraglenoid foramen in primitive position. Two coracoids. No ectepicondylar foramen. A trough dorsally above iliac blade. Posterior branch of Y leads down into prominent stem.

c.—Poliosauridæ. No cleithrum. Supraglenoid foramen far forward. One or two coracoids (the posterior may be unossified). A trough dorsally above iliac blade. The posterior branch of the femoral Y reduced, anterior branch leading to the stem.

d.—Clepsydropidæ. Cleithrum only in *Clepsydrops*. Supraglenoid foramen anterior to supraglenoid buttress. Two coracoids. No ectepicondylar foramen. Formation of iliac blade completed. Stem of femoral Y reduced, anterior branch leading into the rough line marking its position.

e.—Edaphosauridæ. Cleithrum present. Supraglenoid foramen in primitive position. Probably two coracoids. An ectepicondylar foramen present. The ilium is somewhat uncertain. The femoral Y system is much like that of lower cotylosaurs.

The only advanced American form from the Permian not included in the Pelycosauria is *Aræoscelis*. The slim humerus has an ectepicondylar foramen. I am unable to interpret the shoulder girdle. The ilium is of the ophiacodont or poliosaurid type.

The pelycosaurs, as summarized above, are seen to have in their various groups various combinations of primitive and advanced characters. The derivation of the limb structure from that of cotylosaurs is evident, but there is an apparent lack of genealogical sequence between the known pelycosaurian groups themselves, and between certain of them and the typical captorhinomorphs. The latter group cannot be considered as directly ancestral to the Poliosauridæ and Ophiacodontidæ, because of the primitive character of the ilium of these two families, and because of the peculiar femur, with an emphasis of the posterior ridge not found elsewhere, of the latter. *Casea* cannot be derived from any other known pelycosaurian family. The peculiar position of the poliosaurian supraglenoid foramen puts them out of the line of ancestry of the other groups, except possibly the Clepsydropidæ, although their skull is of a generalized nature. The femur of *Ophiacodon* is a debarring specialization. *Edaphosaurus* presents the interesting combination of a limb-structure of extremely primitive character in most respects and recalling only the primitive cotylosaurs, with one startling advance, not found

elsewhere in American cotylosaurs or pelycosaurs—the presence of the ectepicondylar foramen. This structure offers some interesting possibilities as to the possible relationships of the main groups of reptiles. It was certainly developed, at least once, in the cotylosaurian grade of organization, as shown by its presence in the Chelonia as well as possibly in the pareiasaurs; and it is possible that *Edaphosaurus*, with otherwise cotylosaurian limbs, may have been derived from a cotylosaur having this foramen. The foramen is found in lizards and their supposed ancestor, *Aræoscelis;* in *Sphenodon*, but not in other "Diapsids"; in Nothosauria; and in therapsids.

It is, of course, quite probable that the structure has been separately evolved in two or more lines; but it seems extremely improbable that it has been evolved four or five times, as our usual conceptions of the relationships of the groups concerned would involve. It is unwise to base any scheme of classification upon a single character; but, on the other hand, this and other points of girdle and limb structure, which tend to reverse our usual opinions of the relationship of pareisaurs and pelycosaurs other than *Edaphosaurus* to the therapsids, should make us less hasty in coming to a final decision as to therapsid ancestry. It will be noted that even the homology of the lateral temporal fenestra is at stake.

6.—Therapsida

Even in *Moschops*, one of the lowest members of this series, we encounter a new type of structure and function, markedly different from that characterizing the American Permo-Carboniferous fauna and without connecting stages, unless a relationship of therapsids and pareiasaurs be admitted.

Functionally, the changes are those which culminate in the mammals and consist principally in an inturning and more vertical position of the proximal segments of the limbs, with which is associated a partial change in the means of support of these segments from ventral bracing by the muscles of coracoid and pubo-ischiadic plates to a leverage system, with the force exerted by dorsal muscles, from scapular and iliac blades (supra- and infraspinatus in the fore limb, glutei in the hind).

Significant structural characteristics include the following. Cleithrum primitively present. Clavicle and interclavicle present, the latter usually somewhat expanded. Rather tall and well-ossified scapula of primitive type with a single flat surface for the deltoid. No supraglenoid buttress or supraglenoid foramen described. Glenoid not of primitive type. A fairly large coracoid plate of two elements, the anterior entering little if

at all into the glenoid, and the plate not well developed posteriorly. No glenoid foramen. Apparently no point of origin for a coracoid head of the triceps. Humerus with a long and laterally expanded delto-pectoral crest, causing a broad dorsal surface of origin for the brachialis. Median surface for the triceps greatly reduced. The ectepicondylar foramen is present primitively, although absent in *Moschops*, etc. The humerus is comparatively little "twisted." The entepicondylar foramen is turned down to appear on the ventral surface. The ilium is entirely for appendicular muscles externally and is produced forward. The pubis is short and turned out, and its symphysis greatly reduced. The femur is flattened dorso-ventrally, the posterior margin running proximally into the "greater trochanter," left isolated by the loss of connection of its homologue, the posterior branch of the Y ridge system, with the stem and anterior branch. These two latter are reduced in *Moschops*, but somewhat better developed in other and more typical therapsids.

Apart from a few dicynodonts and cynognathids, the limb and girdle material of sure association at my disposal is too scanty and ill-preserved to justify any broad comparisons between the different therapsid groups. Watson has recently reviewed the fore-limb material (1917*a*), and Broom (1913, etc.) had summarized many of the chief points of interest in the history of the group. A number of the factors of advance have been discussed in previous sections. Within the known therapsids, several decided advances have taken place, including the loss of the cleithrum (very late), eversion of the scapular spine and formation of the acromion, the beginning of the formation of a supraspinous fossa, considerable reduction of the coracoid plate, loss (at a number of times, apparently) of the ectepicondylar foramen, further extension forward of the ilium and shortening of the pubis, and development of the greater trochanter of the femur.

It is probably only within the limits of the mammalia, as partially indicated by the monotremes, that a number of other advances have taken place, including the following: the formation of the supraspinous fossa; entire loss of the coracoid plate; loss of the interclavicle; narrowing of the humerus; a secondary narrowing of the ilium and probably acquisition of a trihedral form with the addition to this element of the iliacus origin; and a secondary rounding up of the shape of the femur.

MUSCULAR HOMOLOGIES

The following is a table of the muscular homologies of the limbs of urodeles, reptiles and mammals. In so far as it covers the same territory, it may be considered as a revision of that given by Gregory and

Camp (1918). The innervations (italics) are given, as shown in Figure 1, when of importance. The arrangement followed in the appendicular muscles is that of the proposed division into dorsal and ventral masses. I am indebted to Mr. G. K. Noble for information concerning a number of urodele innervations.

Fore Limb

Body Muscles Acting on the Shoulder Girdle

Urodeles	General Reptilian Condition	General Mammalian Condition
Trapezius (Cucullaris)	Trapezius (Cucullaris) (+Episterno-cleido-mastoideus)	Trapezius +Sterno-cleido-mastoideus
Levator scapulæ	Levator scapulæ (superficialis)	Levator scapulæ (+"Omotrachelius") +Romboideus
Serratus anterior	Serratus anterior Serratus anterior superficialis	Serratus anterior
(Part of Rectus abdomnis)	Sterno-costo-scapularis + Sterno-costo-coracoidei	Subclavius (+Sternoclavicularis)
Omo-hyoid + Sterno-hyoid	Omo-hyoid + Episterno-hyoid	Omo-hyoid + Sterno-hyoid and-thyreoid

Primitive Dorsal Group

Latissimus dorsi	Latissimus dorsi (+Teres major)	Latissimus dorsi (+ Teres major)
Subcoraco-scapularis	Subcoraco-scapularis + Scapulo-humeralis posterior	Subscapularis
Triceps: Scapular head Lateral humeral head Coracoid head Medial humeral head	Triceps: Scapular head Lateral humeral head Coracoid head Medial humeral head	Triceps: Long (scapular) head Lateral humeral head Dorso-epitrochlearis and distal part of old medial head

Primitive Dorsal Group (continued)

Urodeles	General Reptilian Condition	General Mammalian Condition
(Absent or part of extensors)	Brachio (humero)-radialis, *Rad* + Supinator, *Rad*	Brachio-radialis, *Rad* + Supinator, *Rad*
Short radial extensor (part of following) Humero-radialis dorsalis or Extensor carpi radialis + "Supinator"	Short radial extensor + Extensor carpi radialis	Extensor carpi radialis longus + brevis
Extensor digitorum communis	Extensor digitorum communis longus	Extensor digitorum communis + Extensor digiti quinti proprius
Short ulnar extensor (part of following) Extensor carpi ulnaris or Humero-ulnaris dorsalis	Short ulnar extensor + Extensor carpi ulnaris	?Anconæus? + Extensor carpi ulnaris

Primitive Ventral Group

Pectoralis	Pectoralis	Pectoralis
Deltoid (?scapular portion only)	Deltoides scapularis or Dorsalis scapulæ + Deltoides clavicularis	Deltoid, in two or three parts
Precoraco-humeralis, *Ax* + *Spc* Supracoracoideus, *Spc*	Scapulo-humeralis anterior, *Ax* Supracoracoideus, *Spc*	Teres minor, *Ax* Infraspinatus, *Spc* (+ *Ax*) Supraspinatus, *Spc* (+ Supracoracoideus)
Coraco-brachialis brevis + longus, *M-C*	Coraco-brachialis brevis + longus, *M-C*	Coraco-brachialis, *M-C*
Coraco-radialis proprius, *Spc* Brachialis, *M-C*	Biceps, *M-C* Brachialis, *M-C*	Biceps, *M-C* Brachialis, *M-C*
Flexor carpi radialis	Flexor carpi radialis	Flexor carpi radialis + Flexor pollicis longus
(?part of above) Radio-ulnaris	Pronator teres + Pronator profundus or quadratus	Pronator teres + Pronator quadratus

Primitive Ventral Group (continued)

Urodeles	General Reptilian Condition	General Mammalian Condition
Flexor digitorum communis + Flexor digitorum profundus (or ulnari-phalangei II-V)	Flexor digitorum profundus or longus	Palmaris longus + Flexor digitorum sublimis + Flexor digitorum profundus
Short ulnar flexor (part of following) Flexor carpi ulnaris	"Epitrochleo-anconeus" short ulnar flexor Flexor carpi ulnaris	Epitrochileo-anconæus? Flexor carpi ulnaris

Hind Limb
Body Muscles acting on the Pelvis

	Dorsal	
Dorsalis trunci = Caudæ dorsalis	Spinales + Semispinales = Caudæ dorsalis, part Sacrospinalis: Ilio-costalis + Longissimus dorsi = Extensor caudæ lateralis or Caudæ dorsalis, part	Multifidus + Semispinales = Extensor caudæ medialis Sacrospinalis: Ilio-costalis + Longissimus dorsi = Extensor caudæ lateralis or Abductor caudæ externus
	Ventral anterior	
Obliquus externus Obliquus internus Transversus Rectus abdominis	Quadratus lumborum Obliquus externus Obliquus internus Transversus Rectis abdominus	Quadratus lumborum Obliquus externus Obliquus internus Transversus Rectus abdominis + pyramidalis
	Ventral posterior	
Ilio-caudalis + Sacro-caudalis Ilio-caudalis, deep ventral portion Ischio-caudalis, superficial portion	Ilio-caudalis Vestigal except probably in Chelonia	(Ilio-sacro-coccygeus = Levator ani in part) (Pubo-ischio-coccygeus = Levator ani in part) Abductor caudæ inferior or internus, or Flexor lateralis)

Primitive Dorsal Group

Urodeles	General Reptilian Condition	General Mammalian Condition
Ilio-extensorius, *Sac*	Extensor ilio-tibialis, *Crur* + *Sac*	Rectus femoris, *Crur*
Ilio-tibialis, *Crur*	Ambiens, *Crur* Femoro-tibialis, *Crur*	Sartorius, *Crur* Vasti, *Crur*
Ilio-fibularis, *Sac*	Ilio-fibularis, *Sac*	Biceps, *Sac*
Pubo-ischio-femoralis internus (or Ilio-femoralis, in part), *Crur*	Pubo-ischio-femoralis internus, *Crur*	Ilio-psoas, *Crur* + Pectineus, *Crur*
Ilio-femoralis, *Sac* (+*Crur*)	Ilio-femoralis, *Sac* + *Crur*	Glutei (+?tensor fasciæ latæ), *Sac* (+ *Crur*)
"Ischio-femoralis," *Sac*	Ischio-trochantericus, (brevis) (=Pubo-ischio-femoralis posterior), *Sac*	Obturator internus + Gemellii, *Sac*
Femoro-tibialis (2 parts, including "Extensor primitif du tibia," Perrin) Fibulæ metatarsus II	Tibialis anticus=Tibio-metatarsalis longus	Tibialis anticus
Extensor longus digitorum = Femoro-digiti I–V	Extensor longus digitorum = Epicondylo-metatarsalis dorsalis medius	Extensor longus digitorum + Peronæus tertius + ?Extensor hallucis longus
Femoro-fibularis Femoro-tarsali-fibularis	Peronæus anterior + posterior = Fibulo-metatarsalis dorsalis + Femoro-metatarsalis dorsalis	Peronæus longus Peronæus brevis

Primitive Ventral Group

Pubo-ischio-tibialis, *Sac* (+ *Obt*)	Pubo-ischio-tibialis, *Obt* + *Sac*	Gracilis, *Obt*
Pubo-tibialis, *Sac*	Pubo-tibialis, *Obt* + ?*Sac*	
Ischio-flexorius, *Sac*	Flexor tibialis internus, *Obt* + *Sac* Flexor tibialis externus, *Sac*	Semimembranosus, + Semitendinosus, *Sac* (+ *Obt*)

Primitive Ventral Group (continued)

Urodeles	General Reptilian Condition	General Mammalian Condition
"Adducteur du femur," Perrin, *Sac*	Adductor = "Ischio-femoralis," *Obt* + *Sac*	Adductors, *Obt* + *Sac*
Pubo-ischio-femoralis externus, *Obt* + *Sac*	Pubo-ischio-femoralis externus, *Obt* + *Sac*	Obturator externus, *Obt* + Quadratus femoris, *Sac*
Fibulæ metatarsi et digiti I–V + Femoro-fibulæ digiti I-V + Femoro-fibulæ metatarsi I, II, III	Gastrocnemius c. femorale s. externus + Gastrocnemis c. tibiale s. internus + Flexor longus digitorum	 "Triceps suræ" + Plantaris Flexor digitorum longus + ?Flexor hallucis longus
"Rotateur direct du pied," Perrin	Tibialis posticus = Tibio-metatarsalis ventralis	Tibialis posterior
	Fibulo-tibialis superior s. Popliteus	Popliteus
Fibulæ tibialis	Interosseus cruris = Fibulo-tibialis inferior	Interosseus cruris
Caudali-femoralis	Coccygeo-femoralis brevis= Caudi-ilio-femoralis	?Pyriformis
Caudali-pubo-ischio-tibialis	Coccygeo-femoralis longus= Caudi-femoralis	?Cruro-coccygeus

SUMMARY

The following are the chief points presented for the first time or for which additional evidence is presented.

1.—The musculature of tetrapod limbs may be resolved into primitive dorsal and ventral groups, comparable with the two opposing muscle masses of the fish fin.

2.—In the pelvic region especially, these groups are divisible into deeper and more superficial layers, which have primitively double antero-posterior innervations.

3.—The tetrapod shoulder girdle and its muscular relations are comparable to those of the bony fish.

4.—Reduction of the dermal girdle and growth of the scapular blade in tetrapods, as compared with fish, are related to a change in the method of transfer of strain between body and limb.

5.—The trapezius, levator scapulæ, hyoid muscles, deltoid and pectoralis (part) are primitively attached to the dermal girdle. With the loss of the cleithrum the dorsal portions of these insertions and origins were taken over by the scapula.

6.—The muscles of the coracoid plate have invaded the scapular blade in therapsids and mammals, limiting the older musculature (derived from the cleithrum) to spine and acromion.

7.—The great development of the scapular blade and ilium in mammals is due to the changed position of the proximal segments of the limbs, which has enabled muscles advantageously placed to take on a supporting function as levers of the second class.

8.—The coracoid plate muscles concerned in this rotation are the scapulo-humeralis anterior, supracoracoideus, and coraco-brachialis, which are parts of a primitive single deep ventral muscle mass.

9.—The teres minor is the reptilian scapulo-humeralis anterior; the supra- and infraspinatus are derived from the supracoracoideus.

10.—Of the two coracoid elements of primitive and mammal-like reptiles, the modern reptilian "coracoid" is the anterior, and the mammalian coracoid is the posterior. The coracoids of these two groups are not homologous.

11.—The triangular supraglenoid buttress of primitive tetrapods with its musculature (subcoraco-scapularis and long heads of triceps) is comparable to the mesocoracoid bridge of bony fishes. The invasion of the internal surface of the reptilian coracoid by the subcoracoid is related to the disappearance of this buttress and of the postero-dorsal corner of the coracoid and their replacement by the sterno-scapular ligament.

12.—The primitive tetrapod shoulder-joint was composed of two separate although adjacent surfaces.

13.—The primitive humerus was a tetrahedron composed of four roughly triangular surfaces.

14.—The proximal ventral surface was occupied by the coraco-brachialis, the distal ventral by the brachialis. The proximal and distal dorsal surfaces were occupied mainly by lateral and medial heads of the triceps; the proximal surface also by scapulo-humeralis anterior (teres minor).

15.—At the anterior proximal corner were the insertions of the supracoracoideus (supra- and infraspinatus) and, more distally, deltoid and pectoralis. At the posterior proximal corner were the subcoraco-scapularis and, more distally, latissimus dorsi.

16.—At the distal corners were the ect- and ent-epicondyles for origins of flexors and extensors.

17.—The amniote entepicondylar foramen is due to an increase in the area of origin of the flexor muscles and the consequent enclosure of the artery and median nerve.

18.—Anteriorly, a ridge and crest for brachio-radialis and supinator separated dorsal and ventral surfaces. The ectepicondylar foramen is caused by fusion of this crest with the entepicondyle, surrounding part of the radial nerve.

19.—The primitive triceps consisted of four heads, of which the mammals retain only the scapular, lateral humeral, and distal portion of the median humeral heads. The dorso-epitrochlearis is a fusion of part of the primitive median mass with the latissimus.

20.—The tetrapod pelvic girdle consists essentially of (1) a pubo-ischiadic plate, comparable to the fish girdle and bearing comparable dorsal and ventral muscle masses, and (2) an iliac blade, essentially for support, which has interrupted the dorsal muscle mass and taken over the origins of a portion of it.

21.—Pubo-ischio-femoralis internus (ilio-psoas) and ischio-trochantericus (obturator internus) are portions of a primitive deep dorsal mass of which the middle portion (ilio-femoralis) has been taken up by the ilium. These muscles (and the coccygeo-femorales) escape to the external surface beneath the ilio-pubic and ilio- (sacro-) ischiadic ligaments.

22.—The upper portion of the iliac blade was primitively associated with the axial muscles, as in existing urodeles. In the transition to reptiles this portion has folded over on to the inner surface, leaving the external surface free for appendicular muscles.

23.—The increasing importance of the ilio femoralis (gluteals) in the mammalian line, correlated with the changed position of the femur and their supporting function as levers of the second class, has caused the anterior expansion of the ilium and has pushed the ilio-tibialis anteriorly and ventrally as the rectus femoris.

24.—The mammalian sartorius is the ambiens, the origin of which has travelled upwards along the ilio-pubic ligament.

25.—The biceps is the reptilian ilio-fibularis, the origin of which has travelled downwards along the ilio- (sacro-) ischiadic ligament.

26.—The femoro-tibialis (vasti) is an amniote muscle which took over the dorsal surface previously occupied by pubo-ischio-femoralis internus.

27.—Only the internally inserting portions of the long ventral muscles to the lower leg are retained as the mammalian gracilis, semimembranosus, and semitendinosus.

28.—A supra-acetabular (cotyloid) notch is a primitive feature of the hip joint.

29.—A ventral Y-shaped system of ridges is characteristic of the primitive femur. The anterior branch of the Y is the reptilian internal trochanter and, by a change of function, the mammalian minor trochanter. The posterior branch, with the development of the gluteals, becomes the mammalian greater trochanter. The fossa between the two branches always contains the insertion of part of the pubo-ischio-femoralis internus. The junction of the branches is occupied by the insertion of the coccygeo-femoral muscles (fourth trochanter). On either side of the Y-system lie the adductors anteriorly and ilio-femoralis (gluteals) posteriorly.

30.—The limbs of *Diadectes*, a primitive cotylosaur, are essentially of the basic amniote type.

31.—The rachitomous Amphibia differ from the primitive reptiles only in the presence of a small number of probably more primitive characters.

32.—The pareiasaur limb agrees with the therapsid, rather than with the cotylosaurian type.

33.—In limb structure the "pelycosaurs" have no common features other than those attributable to a common cotylosaurian ancestry.

34.—The peculiar distribution of the ectepicondylar foramen suggests that our conceptions of the relationships of many amniote groups may be subject to future revision.

35.—The therapsid type of limb is in sharp contrast to that of primitive groups (except the pareiasaurs) and shows many mammalian tendencies. The changed position of the proximal segments of the limbs is the key to the therapsid and mammalian type of locomotor apparatus.

36.—The detailed characters of the girdles and limbs of therapsids lend strong support to the conclusion that the mammals have been derived from or are closely related to the therapsids, especially the cynodonts.

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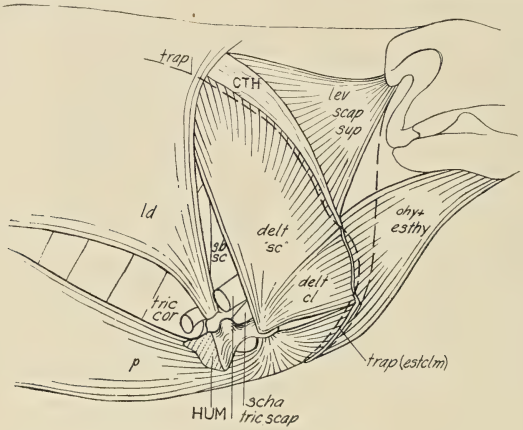
TABLE OF ABBREVIATIONS

ACET.	acetabulum
AC.N	acetabular notch
ACR.	acromion
ad.	M. adductor (s)
ad. br.	M. adductor brevis
ad. l.	M. adductor longus
ad. mg.	M. adductor magnus
ADVL.	anterior dorso-ventral line of humerus
amb.	M. ambiens
anc.	M. anconeus
at. ac.	M. atlanto-acromialis
at. sc.	M. atlanto-scapularis
bi	M. biceps
br.	M. brachio-radialis
bri.	M. brachialis (inferior)
cb.	M. coraco-brachialis
cbb.	M. coraco-brachialis brevis
cbl.	M. coraco-brachialis longus
cd.	M. caudæ dorsalis
cf.	MM. coccygeo-femorales
cfb.	M. coccygeo-femoralis brevis (caudi-ilio-femoralis)
cfl.	M. coccygeo-femoralis longus (caudi-femoralis)
CL.	clavicle
clm.	M. cleido-mastoideus
COR.	coracoid, posterior coracoid
cost. cor.	M. costo-coracoideus
COT.N.	cotyloid notch
cr. cx.	M. cruro-coccygeus
CR. DP.	delto-pectoral crest
CR. SUP.	supinator crest
CTH.	cleithrum
delt.	M. deltoideus
delt. sc.	M. deltoides scapularis
delt. cl.	M. deltoides clavicularis
dep.	M. dorso-epitrochlearis
ecl.	M. extensor caudæ lateralis
ecm.	M. extensor caudæ medialis
ECT.	ectepicondyle
ENT.	entepicondyle
estclm.	M. episterno-cleido-mastoideus
est. hy.	M. episterno-hyoideus
ex.	MM. extensores
excd.	M. extensor communis digitorum
excr.	M. extensor carpi radialis
excu.	M. extensor carpi ulnaris
FE.	femur
FECT.	ectepicondylar foramen
"FECT."	spiral groove, replacing the foramen
FENT.	entepicondylar foramen
FGL.	glenoid foramen
fl.	MM. flexores
flcu.	M. flexor carpi ulnaris
fld.	M. flexor longus digitorum
F. OBT.	obturator foramen
FOR. TH.	thyroid foramen
FOS. SBSC.	subscapular fossa
F. SGL.	supraglenoid foramen
F. SPC.	coracoid, or supracoracoid, foramen
ft.	M. femoro-tibialis
fte.	M. flexor tibialis externus
fti.	M. flexor tibialis internus
gast.	M. gastrocnemius
gem.	MM. gemelli
GLEN.	glenoid
gl. md.	M. gluteus medius
gl. mn.	M. gluteus minimus
gl. mx.	M. gluteus maximus
glut.	MM. glutei
grac.	M. gracilis
HUM.	humerus
ICL.	interclavicle ("episternum")

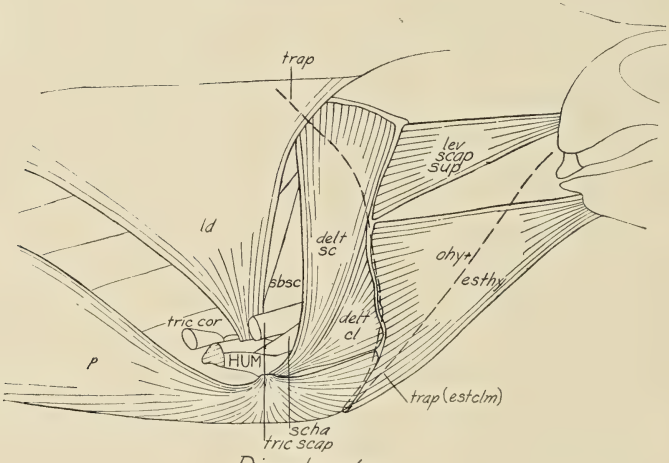
IL.	ilium
ilc.	M. iliacus
il. caud.	M. ilio-caudalis
"il caud"	deep ventral portion of M. ilio-caudalis (=? levator ani)
il. coc.	M. ilio-coccygeus (levator ani, part)
il. cost.	M. ilio-costalis
il. fb.	M. ilio-fibularis
il. fem.	M. ilio-femoralis
il. ps.	M. ilio-psoas
in.	insertion
is. caud.	M. ischio-caudalis
is. coc.	M. ischio-coccygeus (levator ani, part)
isp.	M. infraspinatus
is. tr.	M. ischio-trochantericus
it.	M. (extensor) ilio-tibialis
ld.	M. latissimus dorsi
lev. scap.	M. levator scapulæ
lev. scap. prof.	M. levator scapulæ profundus
lev. scap. sup.	M. levator scapulæ superficialis
lig.	ligament
lig. il.-isch.	ilio-ischiadic ligament
lig. il.-pub.	ilio-pubic ligament
lig. med.	internal lateral ligament of knee
lig. poup.	Poupart's ligament
lig. pub.-isch.	pubo-ischiadic ligament
lig. sch.	scapulo-humeral ligament
lig. stsc.	sterno-scapular ligament
LML.	latero-medial line—separating proximal and distal dorsal surfaces of humerus
long. d.	M. longissimus dorsi
MAR.	marsupial bone
ob. ex.	M. obturator externus
obl.	MM. obliquus internus and externus
obt. int.	M. obturator internus
ohy.	M. omo-hyoideus
or.	origin
p.	M. pectoralis
PCOR.	precoracoid, anterior coracoid of reptiles
pect.	M. pectineus
per.	M. peronæus
per. b.	M. peronæus brevis
per. l.	M. peronæus longus
pife.	M. pubo-ischio-femoralis externus
pifi.	M. pubo-ischio-femoralis internus
pit.	M. pubo-ischio-tibialis
pop.	M. popliteus
prt.	M. pronator teres
ps.	M. psoas
ps. mj.	M. psoas major
ps. mn.	M. psoas minor
pt.	M. pubo-tibialis
(pt.)	part of
PU.	pubis
pub. coc.	M. pubo-coccygeus (levator ani, part)
pyr.	M. pyriformis
qf.	M. quadratus femoris
ql.	M. quadratus lumborum
RA.	radius
r. abd.	M. rectus abdominis
rf.	M. rectus femoris
rh.	M. rhomboideus
sac. coc.	M. sacro-coccygeus (levator ani, part)
SAN.	supra-acetabular notch
sart.	M. sartorius
sbc.	M. subcoracoideus
sbcsc.	M. subcoraco-scapularis
sbsc.	M. subscapularis
SC.	scapula
SCCOR.	scapulo-coracoid
scha.	M. scapulo-humeralis anterior
schp.	M. scapulo-humeralis posterior
ser. ant.	M. serratus anterior

ser. ant. sup.	M. serratus anterior superficialis
sm.	M. semimembranosus
smsp.	MM. semispinales
sp.	MM. spinales
SP.	spine of scapula
spc.	M. supracoracoideus
SR.	articulation with sacral ribs
ssp.	M. supraspinatus
ST.	sternum
st.	M. semitendinosus
st. cl. m.	M. sterno-cleido-mastoideus
st. cor.	MM. sterno-coracoidei
st. hy.	M. sterno-hyoideus
st. m.	M. sterno-mastoideus
subcl.	M. subclavius
sup.	M. supinator
ta.	M. tibialis anticus
t. maj.	M. teres major
t. min.	M. teres minor
trans.	M. transversus abdominis
trap.	M. trapezius
tric.	M. triceps
tric. cor.	M. triceps caput coracoideus
tric. hum.	M. triceps c. humeralis
tric. hum. lat.	M. triceps c. humeralis lateralis
tric. hum. med.	M. triceps c. humeralis medialis
tric. scap.	M. triceps c. scapularis
TR. IN.	internal trochanter
TRL.	transverse line (humerus, ilium)
TR. MJ.	greater trochanter of femur
TR. MN.	minor trochanter of femur
TR. 4	fourth trochanter
TB. IS.	tuberosity of ischium
TUB. PUB.	tuberculum pubis
UL.	ulna.

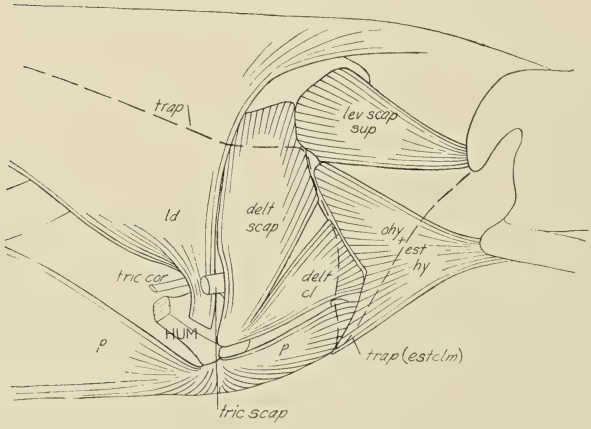
PLATES XXVII TO XLVI



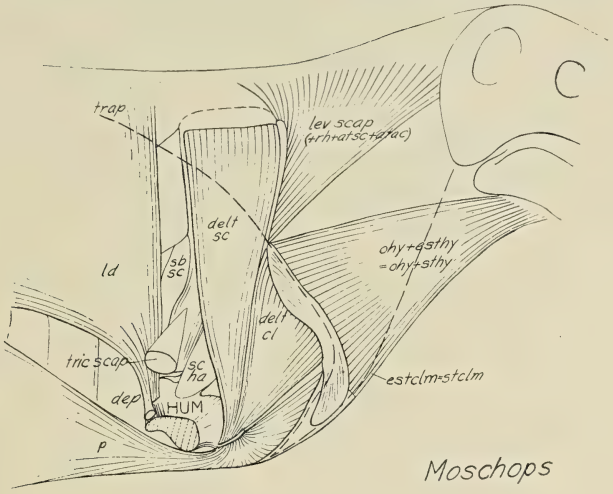
Diadectes



Dimetrodon



Iguana



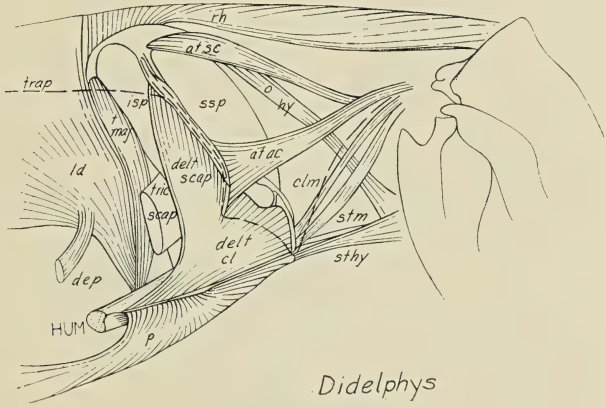
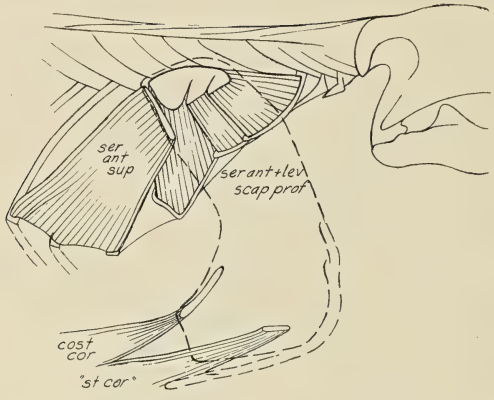
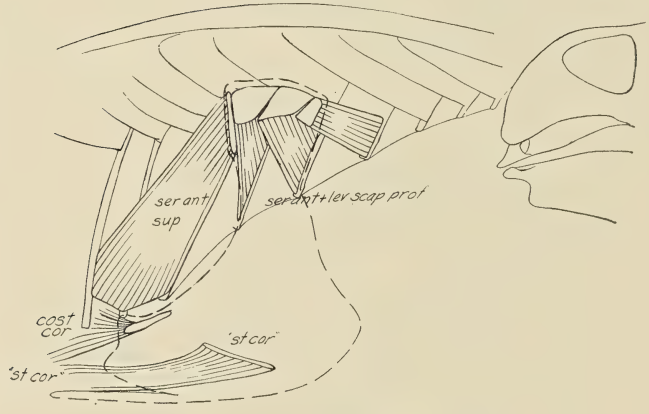


Plate XXVII

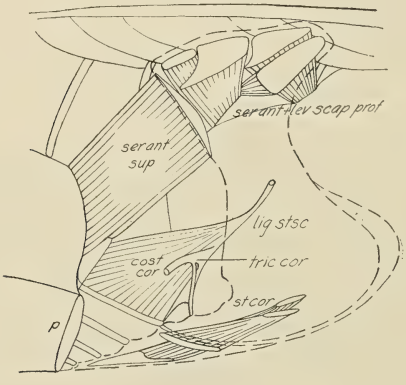
Superficial lateral views of the shoulder musculature of type forms. The trapezius is represented in dotted outline. The relations of this muscle, the levator scapulæ, the hyoid muscles, the deltoid and pectoralis to the dermal girdle will be noted. The superficial portion of the serratus anterior is absent in mammals. The atlanto-acromialis and atlanto-scapularis of *Didelphys* are portions of the levator scapulæ separated by the upgrowth of the supraspinatus. (In this and following figures muscles shown but not treated are given in outline only. A table of abbreviations will be found at the end of the paper.)



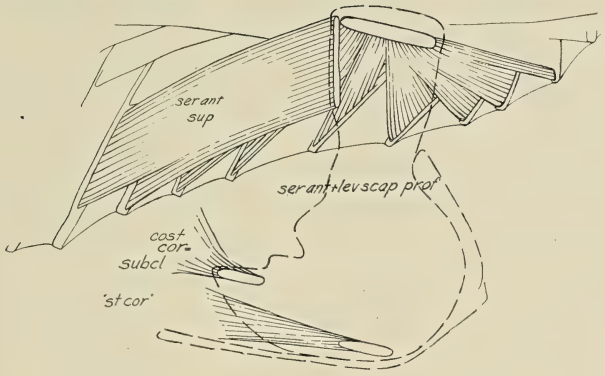
Diadectes



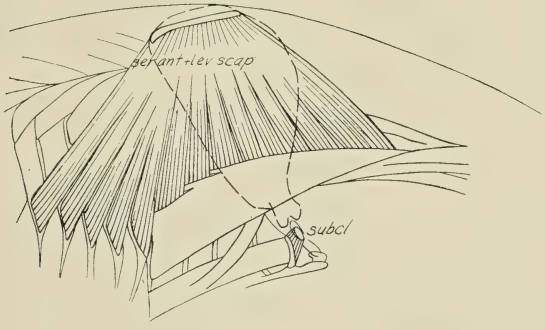
Dimetrodon



Iguana



Moschops



Didelphys

Plate XXVIII

Deep lateral views of the shoulder musculature of types, the shoulder girdle being removed and represented in dotted outline. With the reduction of the reptilian coracoid the costo-coracoideus is seen to insert on the sterno-scapular ligament in *Iguana*. In mammals the posterior ventral muscles are reduced to the subclavius.

Plate XXIX

Internal views of the shoulder region of types, showing the subcoraco-scapularis and posterior ventral body musculature of the girdle. The primitive subcoraco-scapularis probably arose from the shelf above the glenoid (and the inner surface of the scapula) and extends into the inner surface in *Iguana* through loss of the postero-dorsal corner of the coracoid and the evolution of the sterno-scapular (coracoid) ligament.

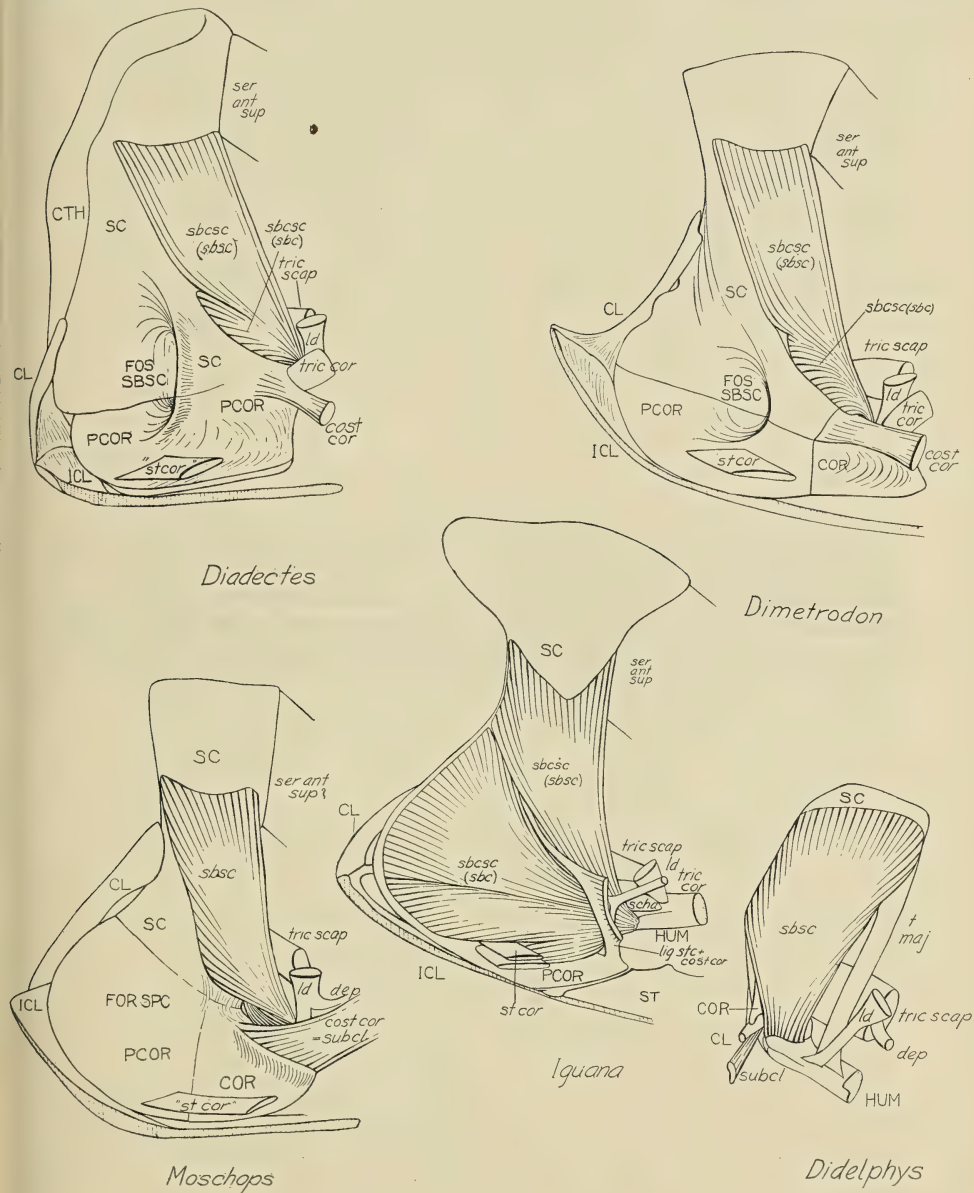
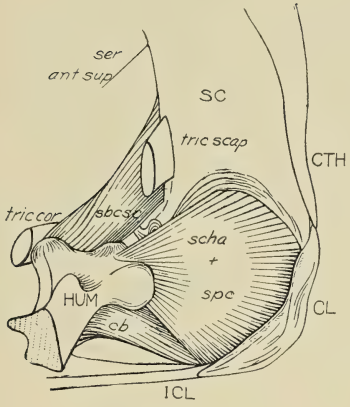
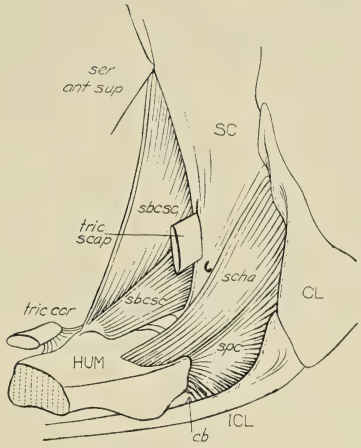

ser ant sup
CTH
SC
sbcsc (sbsc)
sbcsc (sbc)
tric scap
ld
tric cor
CL
FOS SBSC
SC
PCOR
cost cor
PCOR
"st cor"
ICL
Diadectes
ser ant sup
sbcsc (sbsc)
CL
SC
sbcsc(sbc)
tric scap
ld
tric cor
FOS SBSC
PCOR
ICL
st cor
COR
cost cor
Dimetrodon
SC
ser ant sup
sbcsc (sbsc)
CL
tric scap
ld
tric cor
sbcsc (sbc)
scha
HUM
lig stc+cost cor
ICL
PCOR
ST
st cor
Iguana
SC
ser ant sup?
sbsc
CL
SC
tric scap
ld
dep
ICL
FOR SPC
cost cor =subcl
PCOR
COR
"st cor"
Moschops
SC
sbsc
t maj
COR
ld
tric scap
CL
dep
subcl
HUM
Didelphys

Plate XXX

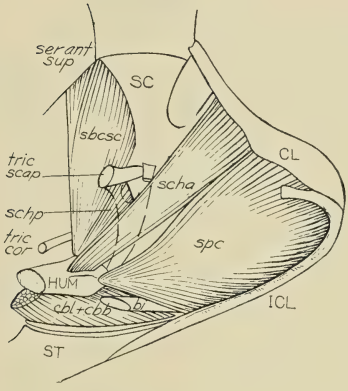
External views of the deep muscles of the shoulder. The original area of origin of the scapulo-humeralis anterior, supracoracoideus and coraco-brachialis is seen as ventral and anterior to the glenoid; it is seen extending dorsally in *Moschops* and *Didelphys*. This group is always anterior to the scapular head of the triceps, as compared with the subcoraco-scapularis group (including scapulo-humeralis posterior) which inserts primitively between coracoid and scapular heads of the triceps.



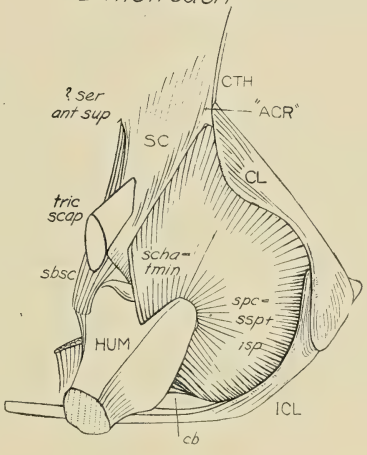
Diadectes



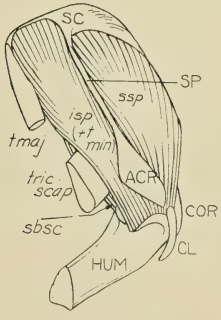
Dimetrodon



Iguana



Moschops



Didelphys

Plate XXXI

Ventral views of shoulder region of types. Above, the relations of the group scapulo-humeralis anterior, supracoracoideus and coraco-brachialis. The dorsal rotation of the group removes all of them from the ventral surface except the coraco-brachialis. The long portion of this muscle is absent in *Didelphys;* its course in other mammals is indicated by an arrow. Below, the biceps, originating from the coracoid plate, and joining with the brachialis to unite in a common primitive insertion on both radius and ulna.

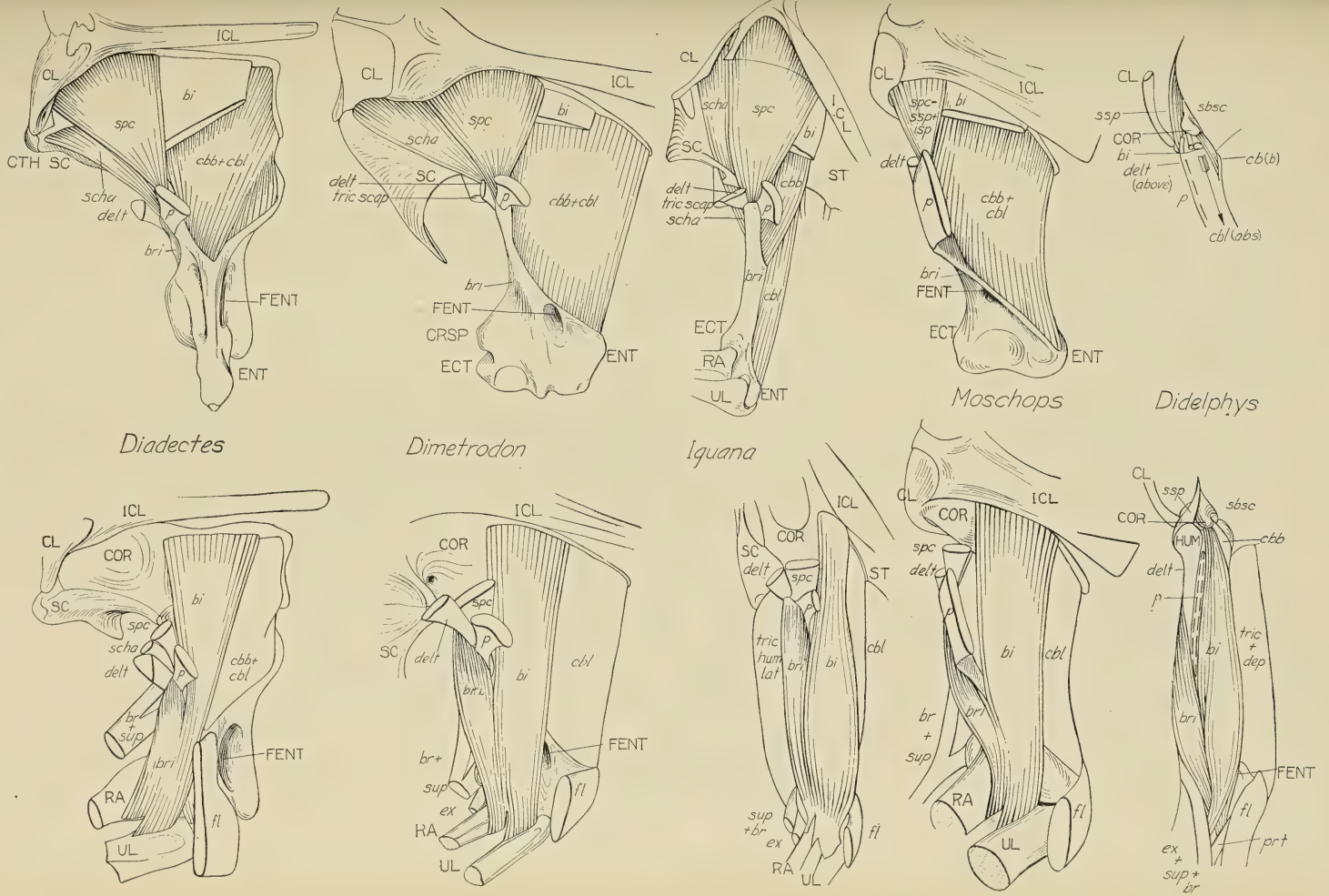
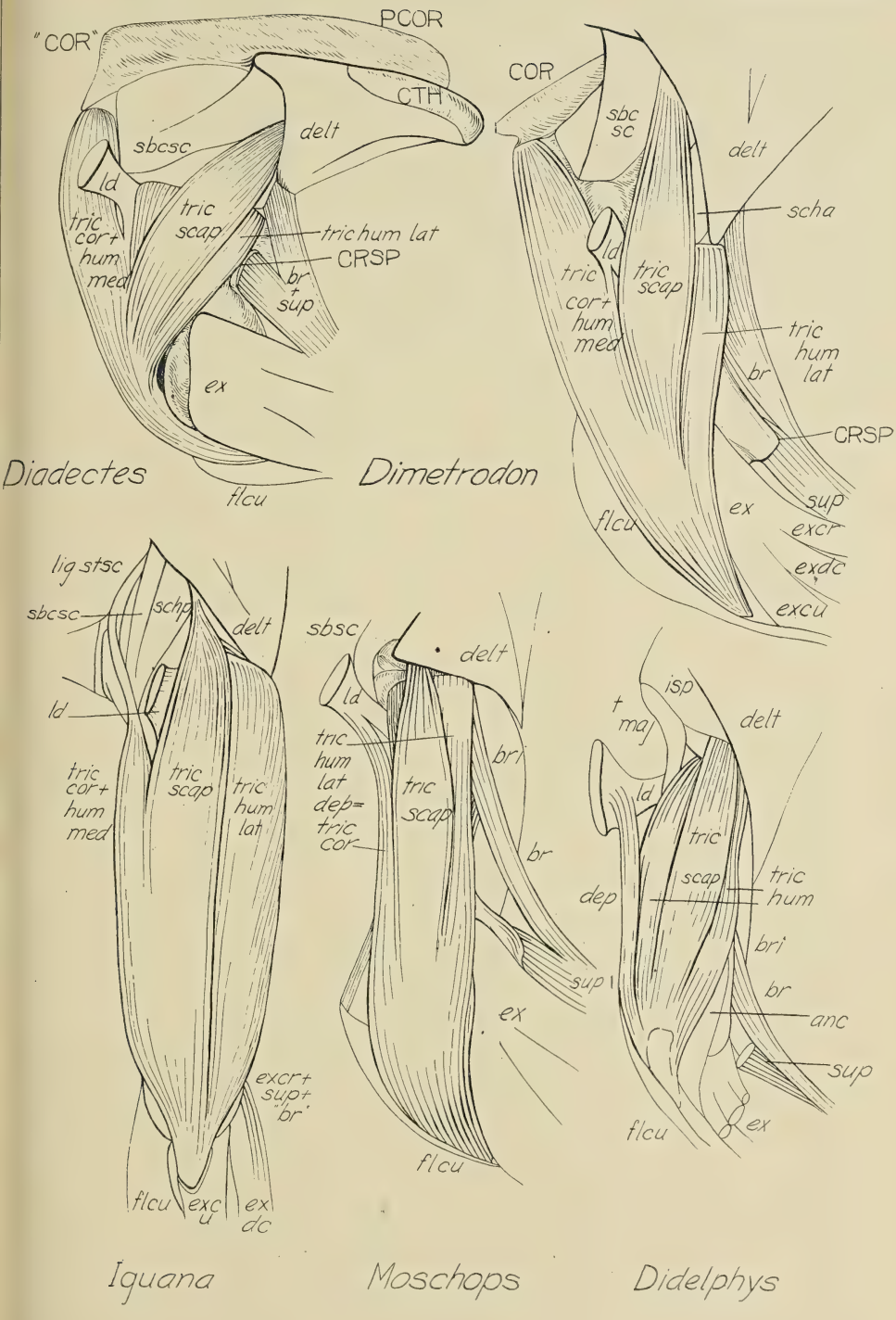

ICL
CL
bi
spc
CTH SC
cbb+cbl
scha
delt
p
bri
FENT
ENT
Diadectes
scha
tric scap
CRSP
ECT
Dimetrodon
RA
UL
Iguana
spc-ssp+isp
Moschops
ssp
sbsc
COR
cb(b)
delt (above)
cbl(abs)
Didelphys
SC
COR
br + sup
fl
ex
HUM
cbb
tric + dep
prt
ex + sup + br

Plate XXXII

Triceps, brachio-radialis and supinator of types. The triceps is divided primitively into (*a*) a lateral (anterior) mass, with a scapular head at the posterior edge of the scapula under cover of the deltoid, and a lateral humeral head (*b*), a medial (posterior) mass, with coracoid and medial humeral heads (the latter not shown, being covered by the former). In mammals, the medial humeral head is reduced to a distal posterior part often (as in *Didelphys*) blended with the lateral head. The dorso-epitrochlearis is a portion of the medial mass primitively connected with latissimus. This latter muscle inserts between the two heads in reptiles, posterior to the triceps in mammals, with loss of the coracoid and part of the medial heads. The supinator and brachio-radialis are shown originating primitively from the supinator crest and anterior dorso-ventral line, and blending with the extensors by fusion of crest and ectepicondyle (this mass is not well developed in *Iguana*).


"COR"
PCOR
CTH
delt
sbcsc
ld
tric cor+ hum med
tric scap
tric hum lat
CRSP
br + sup
ex
flcu
Diadectes
COR
sbc sc
delt
scha
ld
tric cor+ hum med
tric scap
tric hum lat
br
CRSP
ex
sup
excr
exdc
excu
flcu
Dimetrodon
lig stsc
sbcsc
schp
delt
ld
tric cor+ hum med
tric scap
tric hum lat
excr+ sup+ br
flcu
exc u
ex dc
Iguana
sbsc
delt
ld
tric hum lat dep= tric cor
tric scap
bri
br
sup
ex
flcu
Moschops
isp
t ma
delt
ld
tric
scap
tric hum
dep
bri
br
anc
sup
flcu
ex
Didelphys

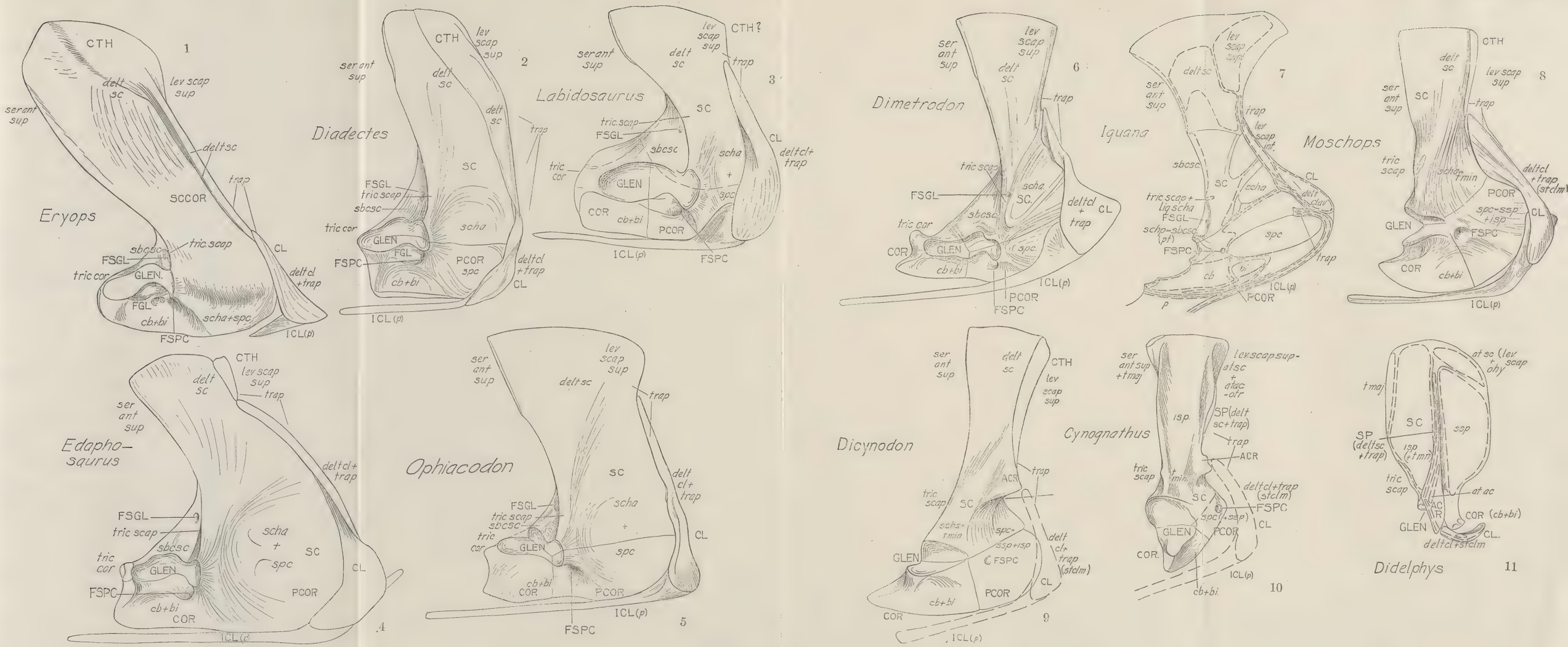
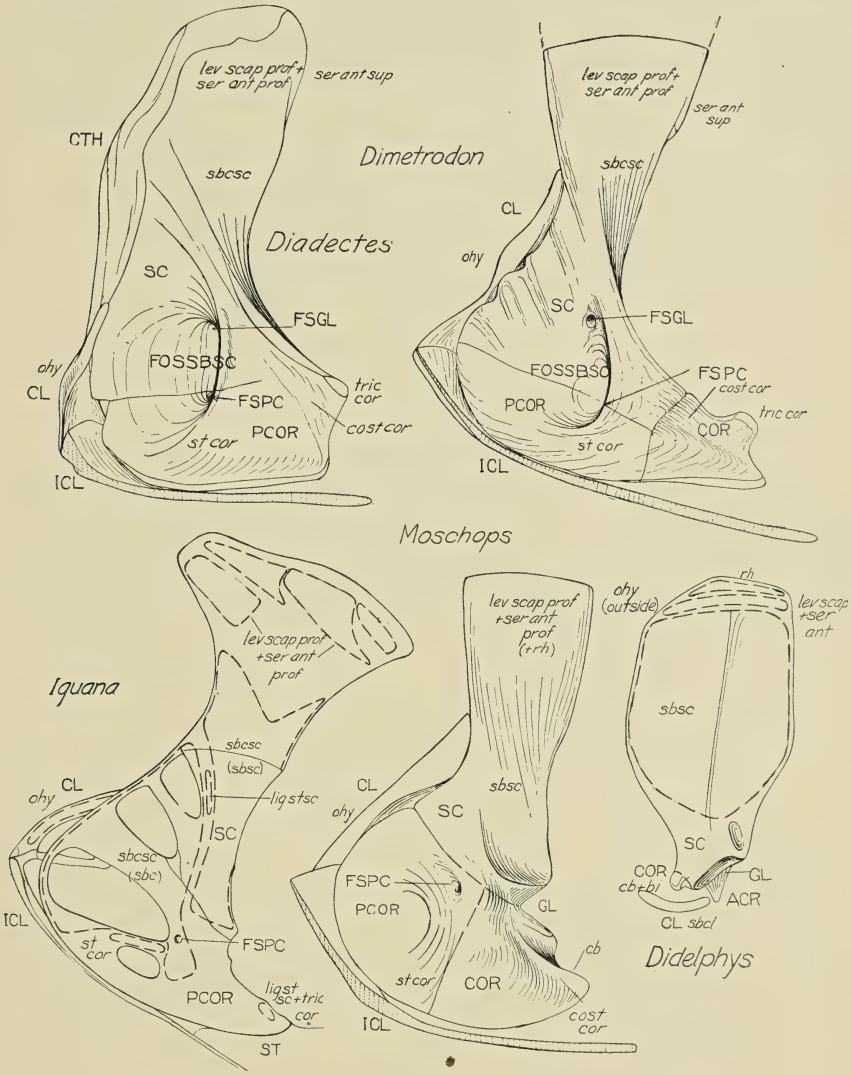


Plate XXXIII

External view of shoulder girdles of various tetrapods. The reduction of the primitive dermal girdle and the transfer of its musculature to the scapula, and the later spine and acromion is shown. The primitive ventral and anterior position of the deep ventral musculature and its upward movement in the mammalian line is indicated. The relations of the coracoid (except in *Edaphosaurus*), the supraglenoid buttress, the primitive foramina, and the scapular and coracoid heads of the triceps, are shown.



Internal views of the shoulder girdles of types, showing the muscular insertions.

Plate XXXV

Proximal and distal dorsal surfaces of humeri of types. The latero-medial line separates the two dorsal surfaces; in *Moschops* and *Didelphys* the proximal portion of the distal dorsal surface is reduced. The anterior line separating dorsal and ventral surfaces appears far dorsally in *Moschops* and *Didelphys*. The ectepicondylar foramen is present in *Iguana*, but absent in *Moschops*, where the spiral groove represents its old position (see also Plate XXXVII).

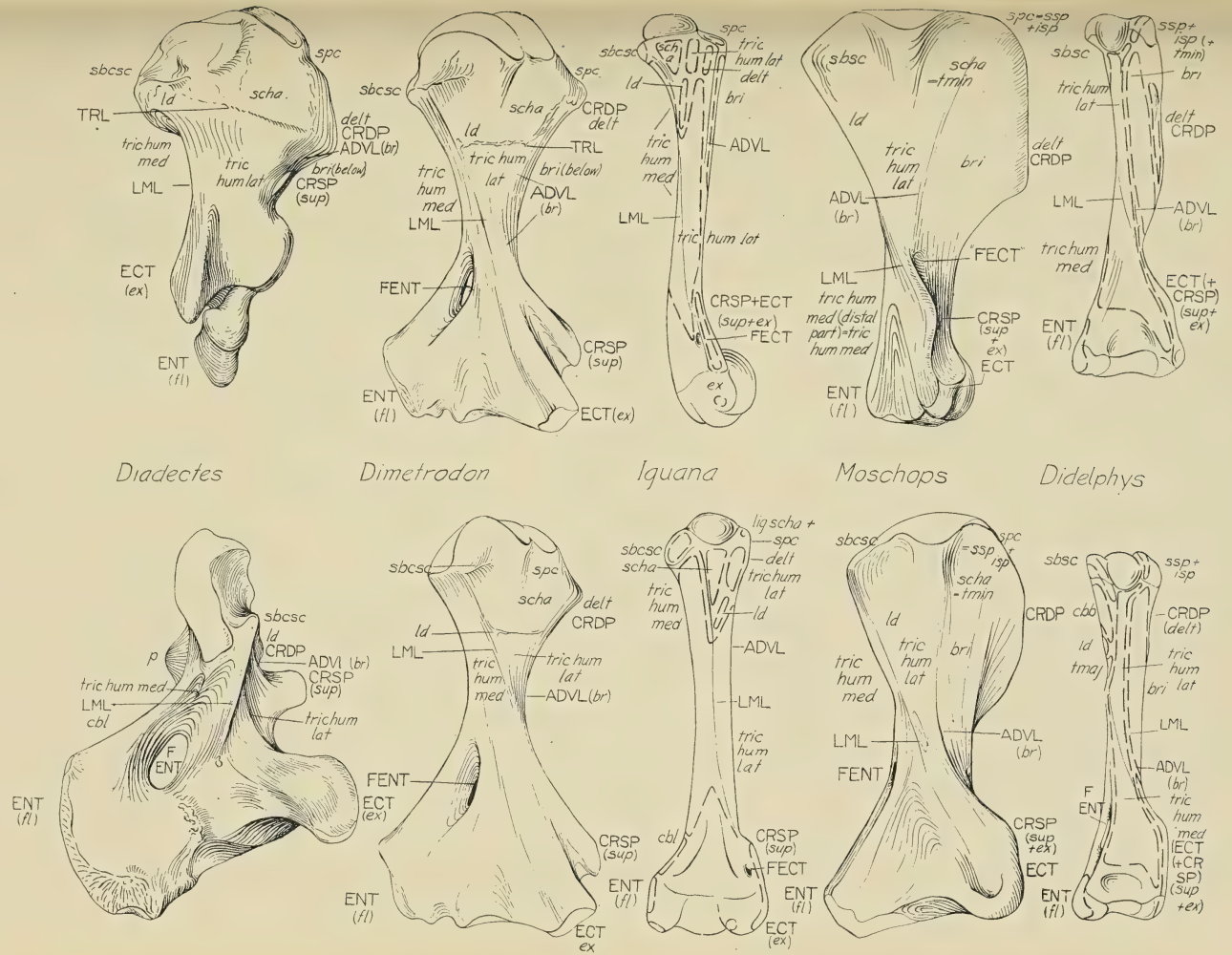

sbcsc
spc
ld
scha
TRL
delt
CRDP
ADVL(br)
tric hum med
tric hum lat
bri(below)
LML
CRSP (sup)
ECT (ex)
ENT (fl)
CRDP delt
ADVL (br)
FENT
ECT(ex)
sch a
bri
CRSP+ECT (sup+ex)
FECT
ex
scha =tmin
spc=ssp +isp
ssp+ isp (+ tmin)
ADVL
Diadectes
Dimetrodon
Iquana
Moschops
Didelphys
p
F ENT
lig scha +
cbl
tmaj

Plate XXXVI

Proximal and distal ventral surfaces of humeri of types. The coraco-brachialis occupies the proximal surface, the longer portion inserting on the narrow distal ridge as in *Iguana* and many mammals (absent in *Didelphys*). The distal ventral surface is occupied by the brachialis which in the mammalian line (last two figures) extends proximally above the delto-pectoral crest to appear as part of the dorsal surface (compare Plates XXXV and XXXVII).

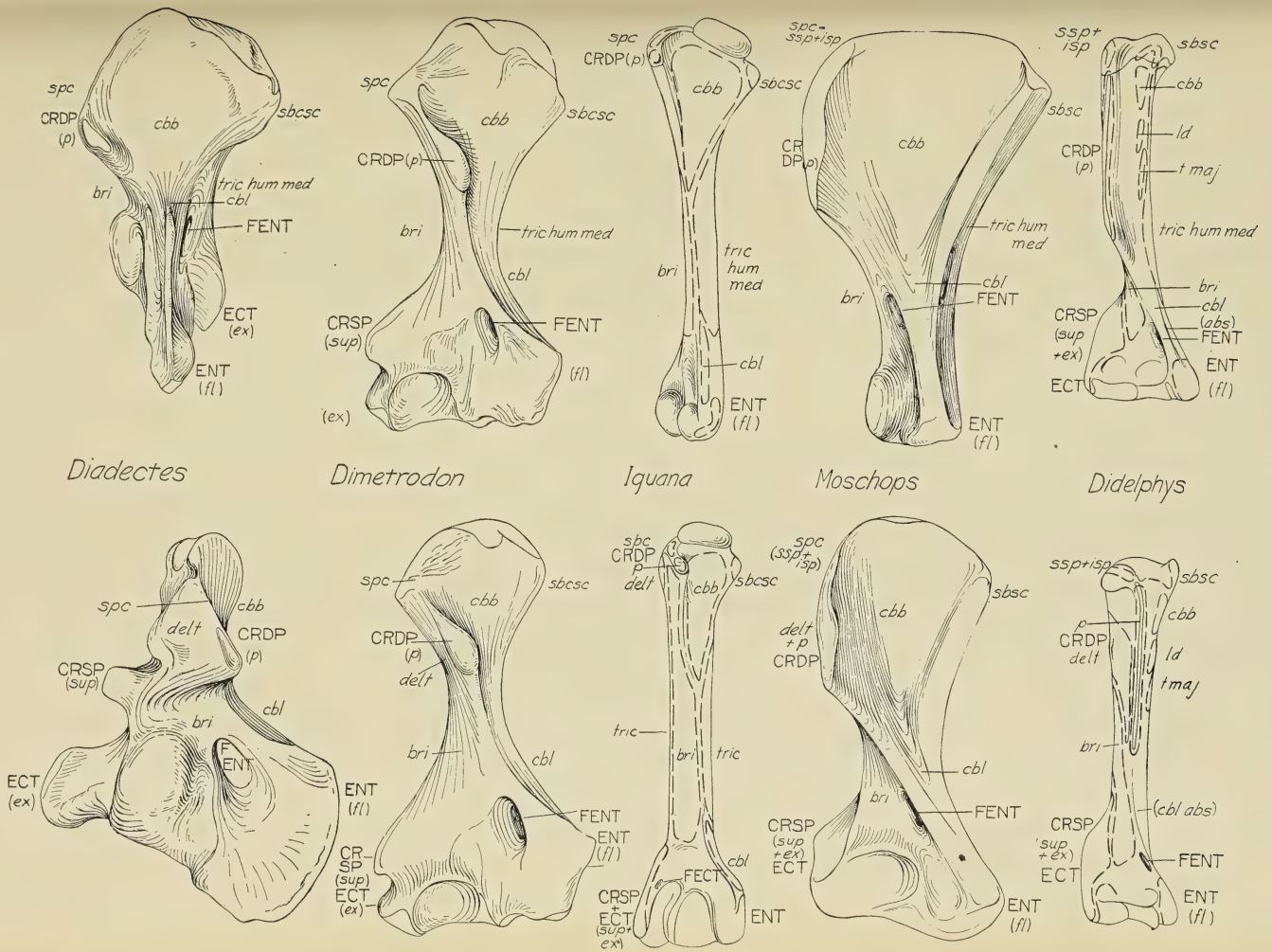
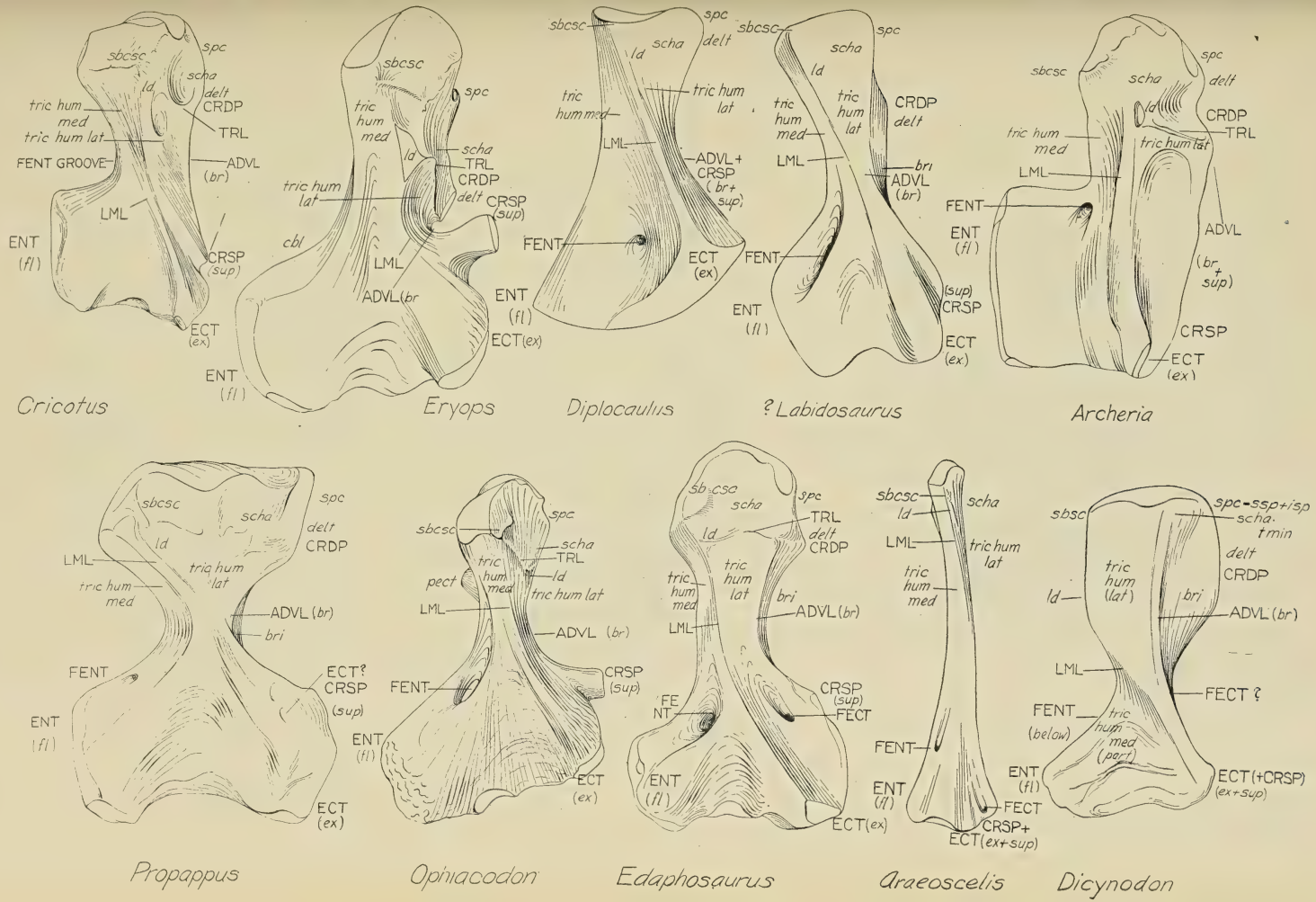
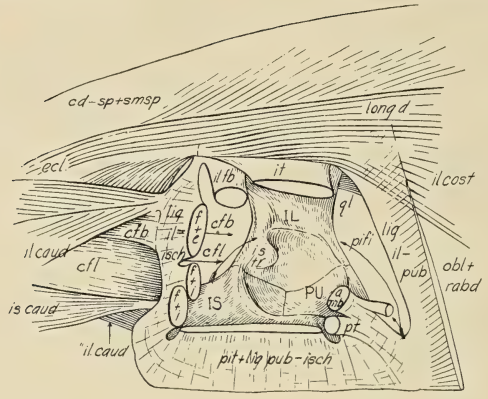

spc
CRDP (p)
cbb
sbcsc
bri
tric hum med
cbl
FENT
ECT (ex)
ENT (fl)
Diadectes
spc
cbb
sbcsc
CRDP(p)
bri
tric hum med
cbl
CRSP (sup)
FENT
(fl)
(ex)
Dimetrodon
spc
CRDP(p)
cbb
sbcsc
bri
tric hum med
cbl
ENT (fl)
Iguana
spc-ssp+isp
sbsc
cbb
CR DP (p)
tric hum med
bri
cbl
FENT
ENT (fl)
Moschops
ssp+ isp
sbsc
cbb
ld
CRDP (p)
t maj
tric hum med
bri
cbl (abs)
FENT
CRSP (sup +ex)
ECT
ENT (fl)
Didelphys
spc
cbb
delt
CRDP (p)
CRSP (sup)
bri
cbl
ECT (ex)
ENT
ENT (fl)
spc
cbb
sbcsc
CRDP (p)
delt
bri
cbl
FENT
CR SP (sup) ECT (ex)
ENT (fl)
spc CRDP p delt
cbb
sbcsc
tric
bri
tric
cbl
FECT
CRSP + ECT (sup+ ex)
ENT
spc (ssp+ isp)
sbsc
cbb
delt +p CRDP
cbl
bri
FENT
CRSP (sup +ex) ECT
ENT (fl)
ssp+isp
sbsc
p
CRDP
delt
cbb
ld
t maj
bri
(cbl abs)
CRSP (sup +ex)
ECT
FENT
ENT (fl)

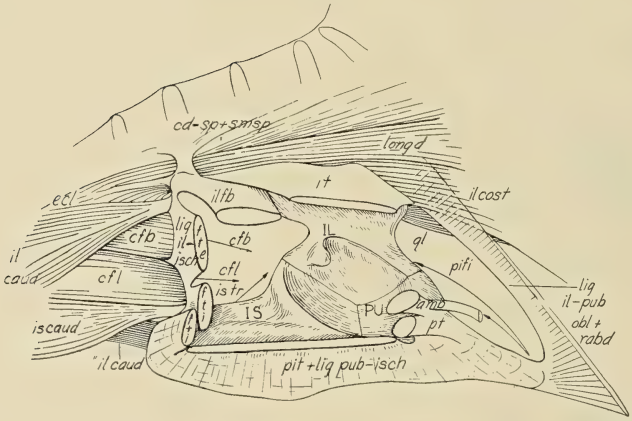
Plate XXXVII

Humeri of various Amphibia and Reptilia, drawn on the plane of the distal dorsal surface (compare with Plate XXXV). The entepicondylar foramen is not present in *Cricotus* and *Eryops*, except as a groove in the former, in the position indicated. It is found in all the other forms shown, although turned ventrally in *Dicynodon*. The shape of the *Propappus* humerus leads to the suggestion that the ectepicondylar foramen was present, although not described. This foramen is formed by the fusion of the supinator crest seen in earlier forms, with the ectepicondyle, and is shown in the last three humeri.

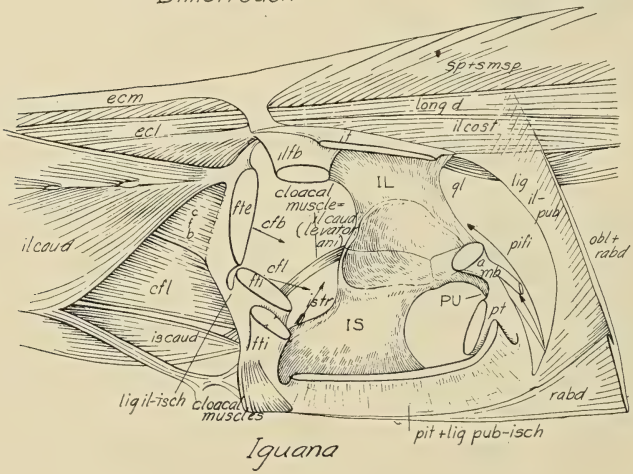

sbcsc
spc
scha
ld
delt
CRDP
tric hum med
tric hum lat
TRL
FENT GROOVE
ADVL (br)
LML
ENT (fl)
CRSP (sup)
ECT (ex)
Cricotus
cbl
ADVL (br
Eryops
tric hum lat
Diplocaulus
FENT
ECT (ex)
? Labidosaurus
bri
(sup) CRSP
Archeria
ADVL (br + sup)
CRSP
Propappus
ECT? CRSP (sup)
pect
Opisthacodon
FE NT
FECT
Edaphosaurus
Araeoscelis
CRSP+ ECT (ex+sup)
spc-ssp+isp
scha.
tmin
tric hum (lat)
FECT ?
FENT (below)
tric hum med (part)
ECT (+CRSP) (ex+sup)
Dicynodon



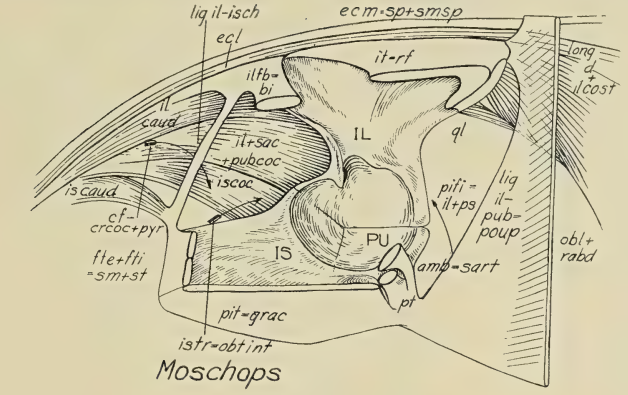
Diadectes



Dimetrodon



Iguana



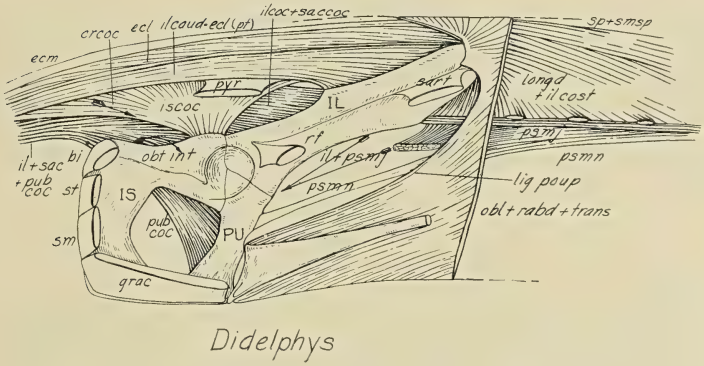


Plate XXXVIII

Lateral views of the pelvic region of type forms, with the axial musculature and cut ends of the longer appendicular muscles. The system of ligaments from which and under which many of the limb muscles arise are shown (except the sacro-ischiadic ligament of *Didelphys*). The inner system of ventral caudal muscles, the "levator ani" (ilio-, sacro-, pubo- and ischio-coccygeus) is absent in *Iguana*, except for a small slip. This system is restored, similar to the amphibian deep portion of "ilio-caudalis" in *Moschops*, *Diadectes* and *Dimetrodon*. The ischio-caudalis of reptiles is absent in *Didelphys*.

Plate XXXIX

Superficial dorsal views of the pelvic musculature of types. The triceps (quadriceps and sartorius), ilio-fibularis (biceps) and ilio-femoralis (glutei). The ilio-tibialis (rectus) is cut in the first four figures, and the gluteus maximus and medius in *Didelphys*. The growth of the glutei has pushed the ilio-tibialis forward and ventrally to become the rectus. The ilio-fibularis has migrated down the ilio- (sacro-) ischiadic ligament to become the biceps; the ambiens has migrated up the ilio-pubic ligament to become the sartorius.

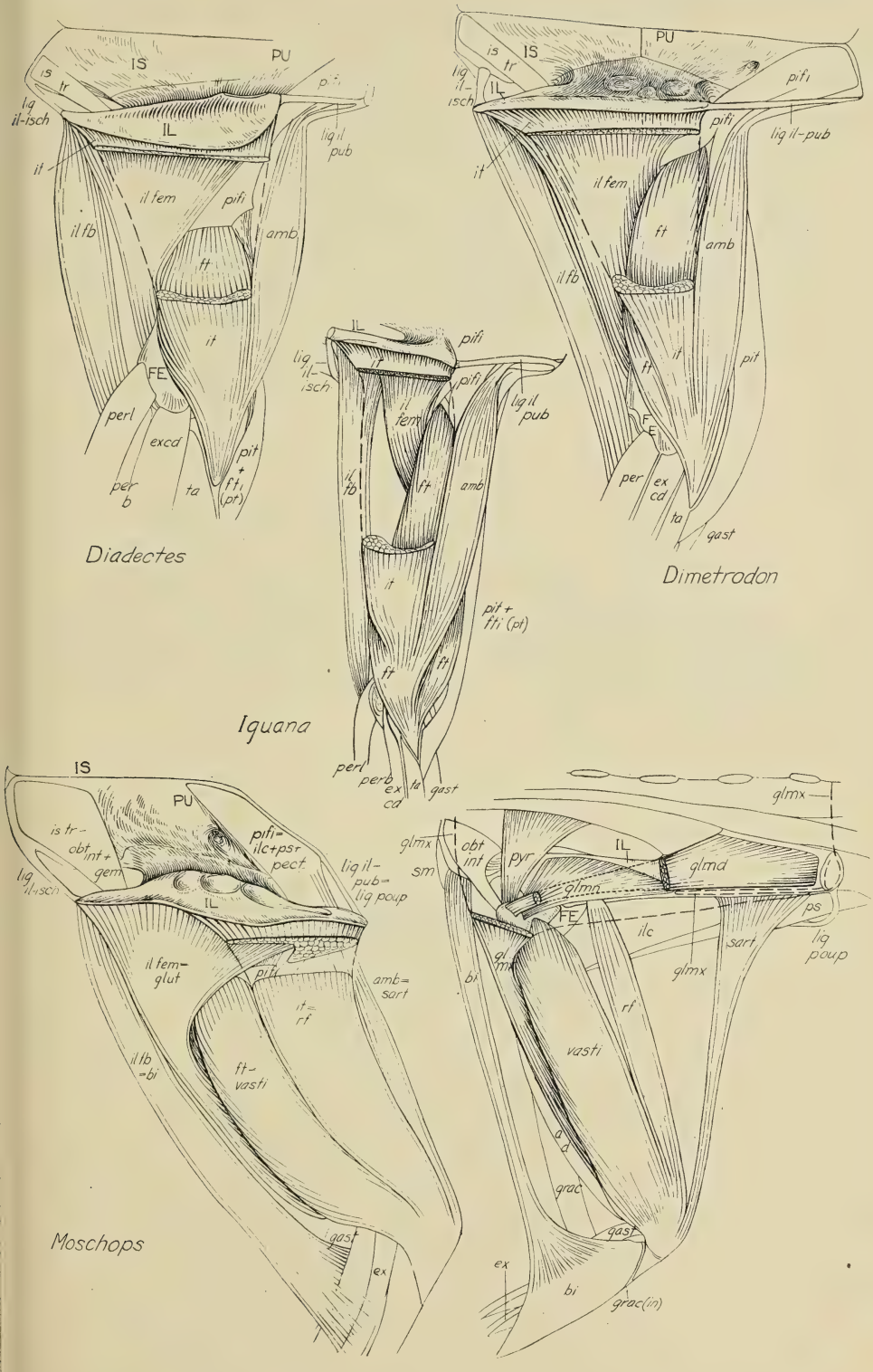

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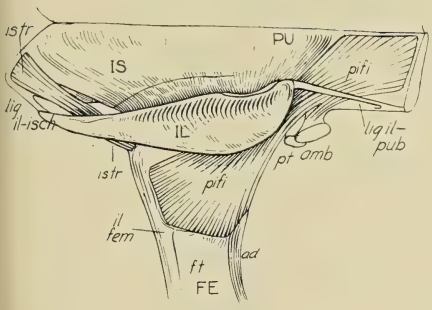
Plate XL

Deep dorsal views of the pelvic musculature of types. The pubo-ischio-femoralis internus and ischio-trochantericus are seen emerging beneath the ligaments. The reduction of the insertion and change of origin in mammals of the pubo-ischio-femoralis internus (ilio-psoas) are shown. (The pectineus, part of the latter, is shown in a ventral view.)



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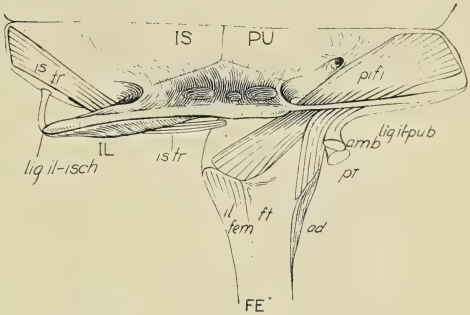
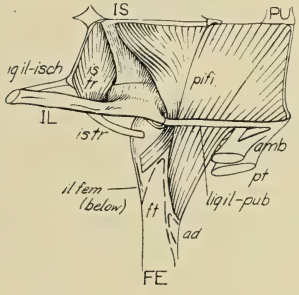
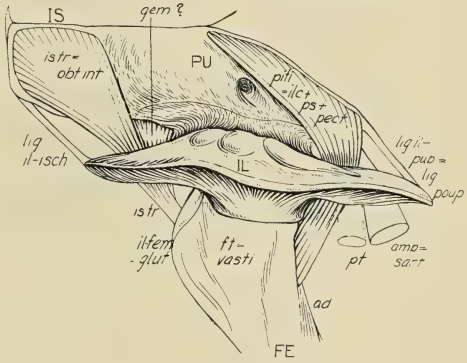


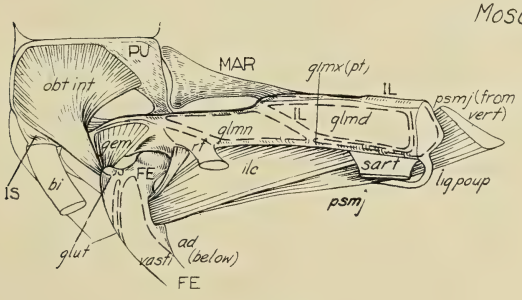
Dimetrodon



Iguana



Moschops



Didelphys

Plate XLI

Superficial ventral views of the pelvic musculature of types. The long ventral muscles are shown (a portion of them is cut to expose the deeper layers). It is impossible to determine the number of slips in the extinct forms; they have been restored by comparison with lizards and *Sphenodon*. Note that the mammalian representatives of this group are merely those portions which insert internally on the tibia, as contrasted with the large reptilian mass inserting between the two heads of the gastrocnemius.

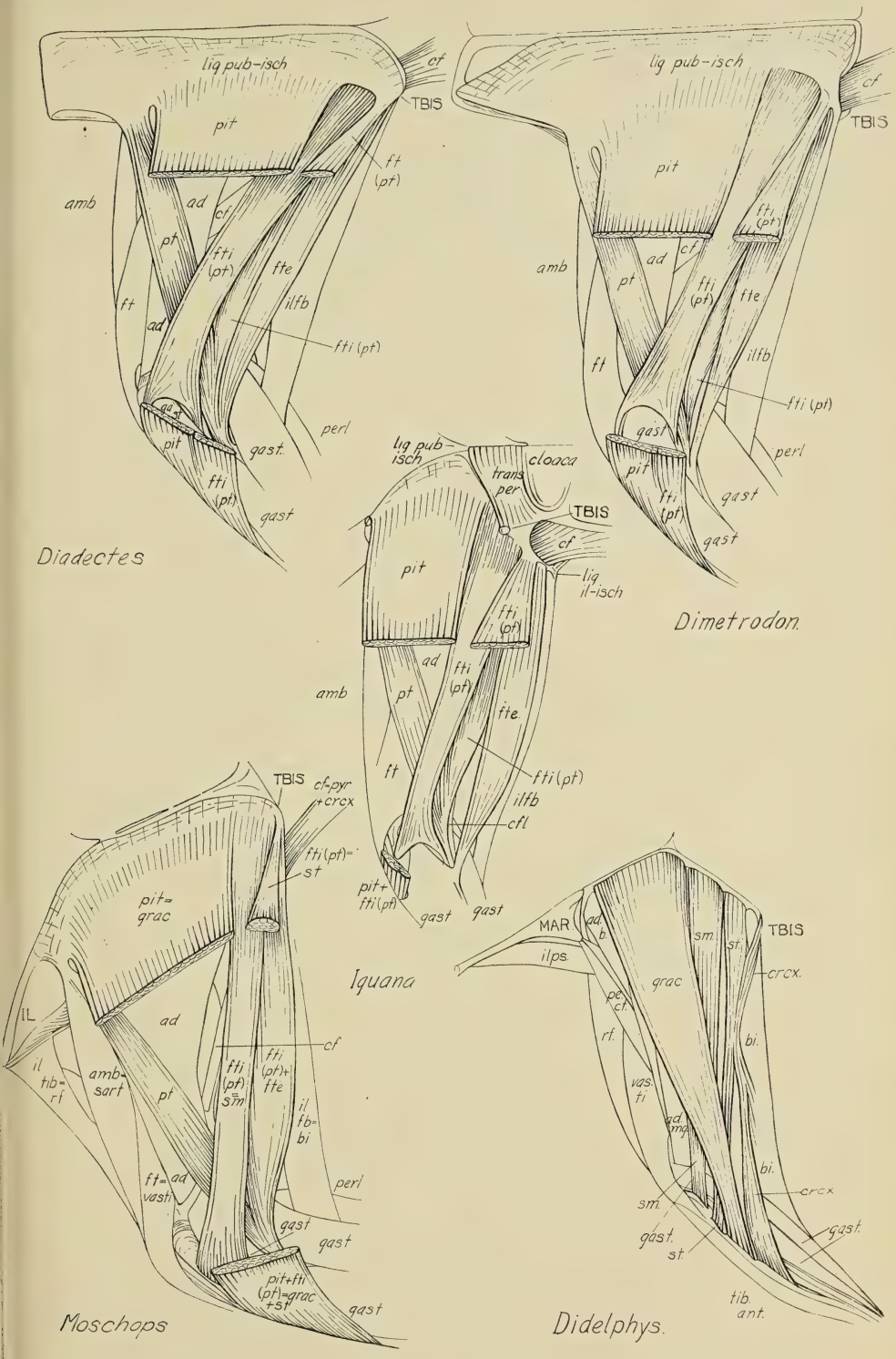

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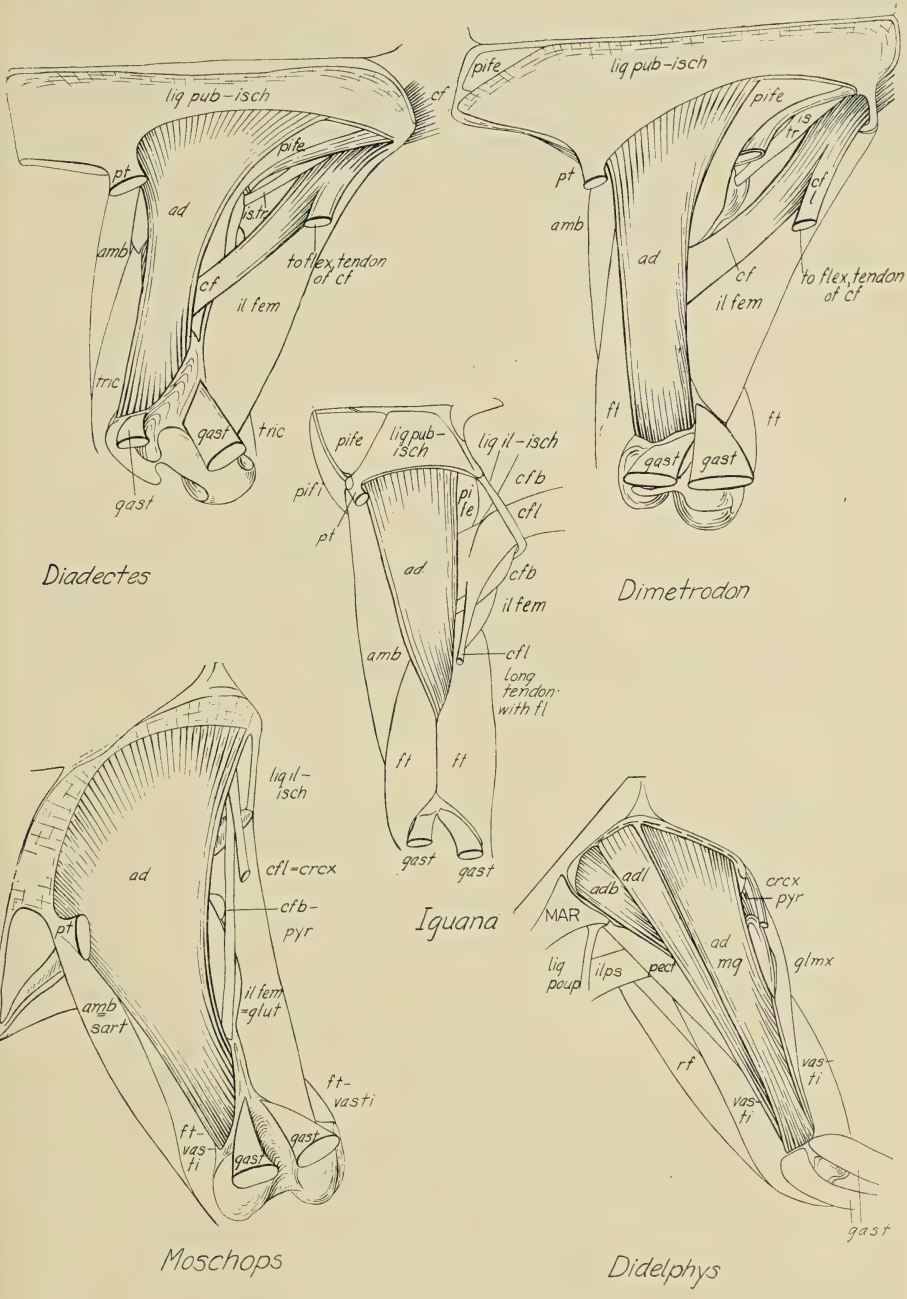
Plate XLII

Ventral views (long flexors removed) of the pelvic musculature of types. The primitive adductor mass and its relations with neighboring muscles. In both this and the preceding plate the coccygeo-femorales are seen in part.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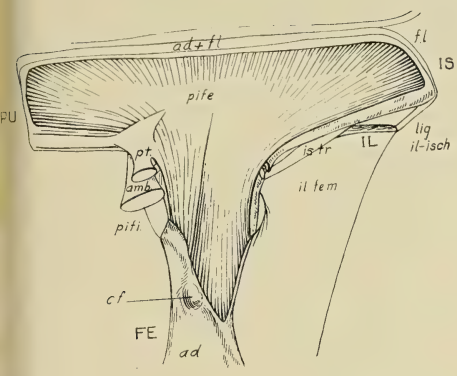
Didelphys

Plate XLIII

Deep ventral views of the pelvic musculature of types. The pubo-ischio-femoralis externus and its derivatives, the obturator externus and quadratus femoris. (The pectineus of *Didelphys* belongs to the dorsal series, with pubo-ischio-femoralis internus.)



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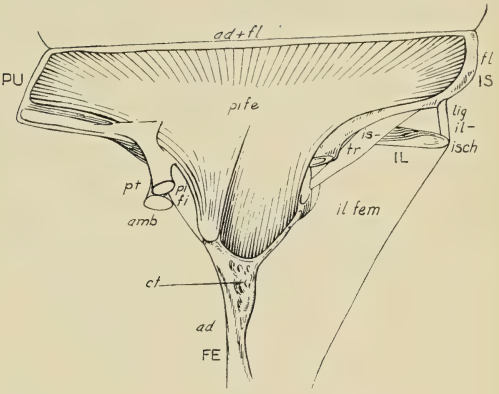
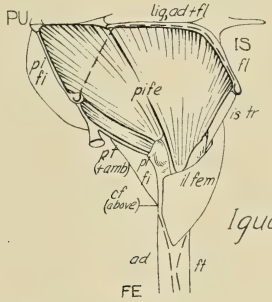
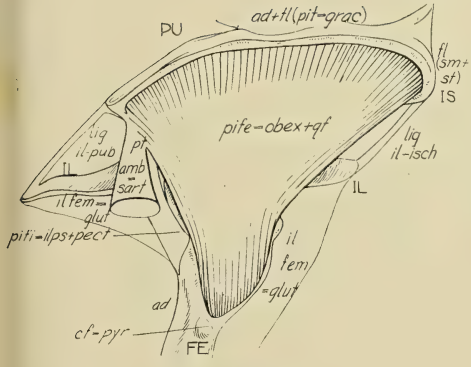


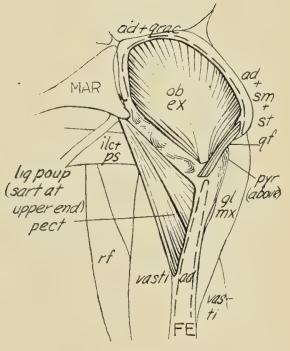
Dimetrodon



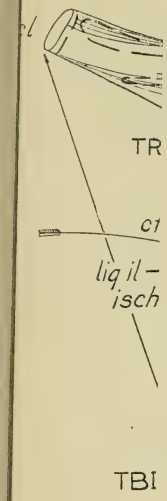
Iguana



Moschops



Didelphys



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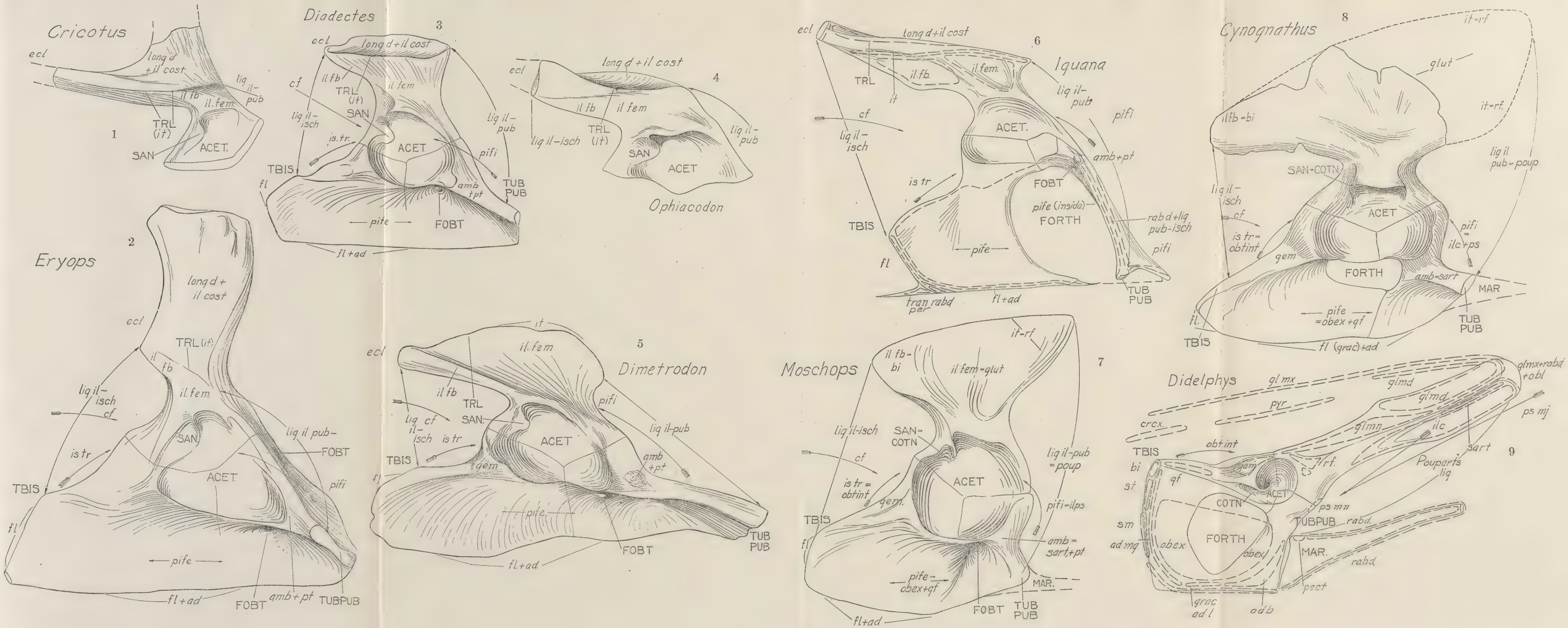


Plate XLIV

External views of the pelves of various tetrapods. The ligaments, except the sacro-ischiadic of mammals, are indicated by arrows. Short arrows show the emergence of internal and caudal muscles beneath the ligaments. The transverse line of *Cricotus* and *Eryops* is seen to become the dorsal edge of the ilium of *Dimetrodon* and later forms. The anterior expansion of the ilium in the therapsid-mammal series is indicated (the dotted lines above the *Didelphys* ilium indicate muscles which have transferred their origin to the back fascia and vertebræ).

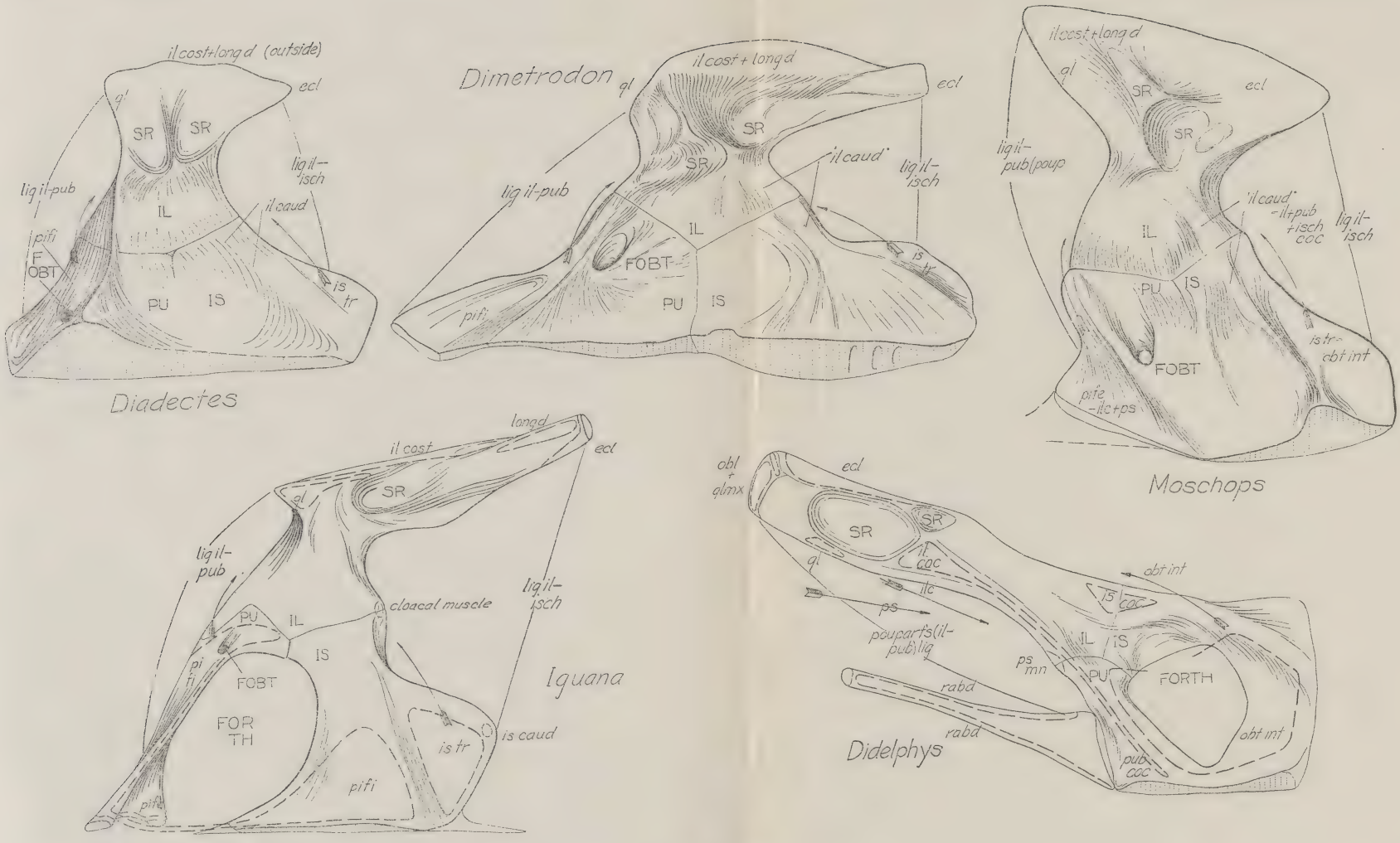
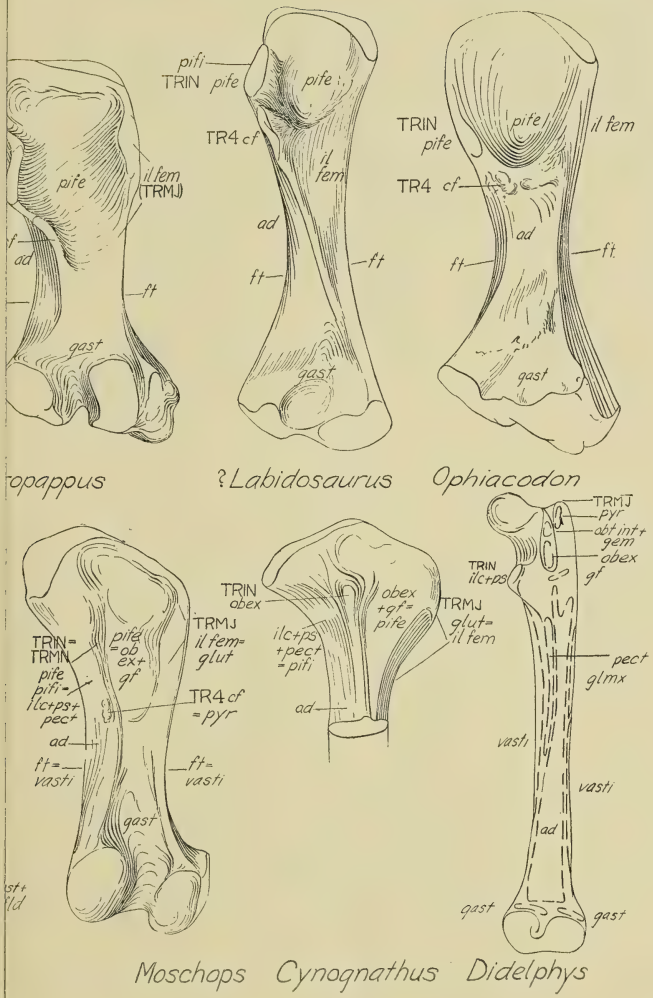


Plate XLV

Internal views of the pelvic girdles of types. The surfaces for pubo-ischio-femoralis internus anteriorly and ischio-trochantericus posteriorly are primitively well-marked, and their courses out beneath the ilio-pubic and ilio- (sacro-) ischiadic ligaments are represented by short arrows. The former muscle has spread inside the girdle in *Iguana*, the latter (obturator internus) in *Didelphys*. The ilio-psoas (pubo-ischio-femoralis internus) has abandoned its original area of origin in mammals. The ridge anterior to the ischio-trochantericus probably represents the insertion of the deep portion of the ilio-caudalis, lost except as a cloacal muscle in reptiles and represented by the ilio-sacro-pubo-ischio-coccygeus of mammals (levator ani).



s internus, this being limited to the proximal portion by the anter, associated with the former muscle (=the gluteals) is n and mammalian trochanters is illustrated (compare figure 6).

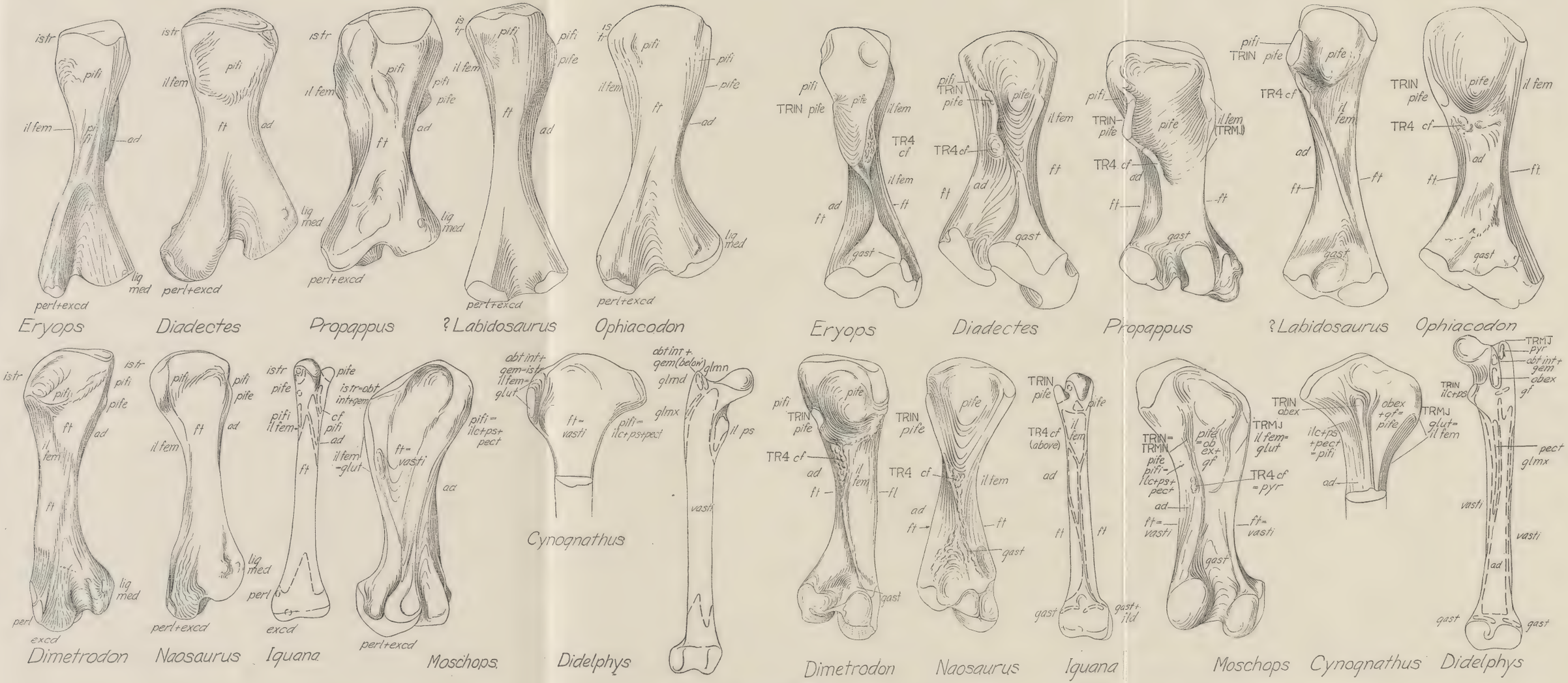


PLATE XLVI

Femora of various tetrapods, dorsal views at left, ventral views at right. The dorsal surface is primitively occupied by the pubo-ischio-femoralis internus, this being limited to the proximal portion by the growth of the femoro-tibialis, seen distally in *Eryops*. The ilio-femoralis is found posteriorly, the adductors anteriorly. The growth of the greater trochanter, associated with the former muscle (=the gluteals) is seen in the last three femora. Ventrally the primitive system of ridges is especially well seen in *Eryops* and *Edaphosaurus*. The transformation to the reptilian and mammalian trochanters is illustrated (compare figure 6).

59.81(72.2)

Article XI.—THE AMPHIBIANS AND REPTILES OF LOWER CALIFORNIA AND THE NEIGHBORING ISLANDS

By Karl Patterson Schmidt

Plates XLVII to LVII

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Geographic Analysis of the Herpetological Fauna	611
Speculations on the Origin of the Fauna	626
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INTRODUCTION

A general account of the "Albatross Expedition" of 1911 has been given by Dr. C. H. Townsend in the first paper of the Scientific Results (1916, Bull. Amer. Mus. Nat. Hist., XXXV, pp. 399–476, 45 figs., 1 map). That paper contains the itinerary of the expedition, many valuable notes on habitat conditions, and especially photographs illustrating the topography and vegetation at the localities where collections of amphibians and reptiles were made. The additional photographs showing habitat conditions in the present paper have been kindly furnished by Dr. Townsend.

As has already been stated in other papers, the expedition was made possible largely through the generous support of Mr. Arthur Curtiss James, Trustee of The American Museum of Natural History, to whom the Museum is consequently indebted for the splendid Lower Californian collections discussed below.

The collections made by the Albatross Expedition in 1911 contain four hundred and forty-eight specimens of reptiles and seven amphibians, representing two species of amphibians and sixty-one species of reptiles. In a previous paper, Dickerson (1919, Bull. Amer. Mus. Nat. Hist., XLI, pp. 461–477) has described a new genus and twenty-three new species from the Albatross collection, of which sixteen are recognized in the present paper. To these must be added three forms described below, making a total of nineteen forms new to science contained in the collection. Perhaps the most important part of the collection is the material

secured on the islands of the Gulf of California, many of which had not been visited previously by a scientist, while some additions are made to the faunæ of even the better known islands.

In connection with the work on the Albatross collection, the Field Museum of Natural History in Chicago has kindly loaned a part of the Heller collection from the northern part of the peninsula, which has been especially valuable for comparison with the distinct fauna of southern Lower California. The United States National Museum has loaned the valuable collection of Lower Californian amphibians and reptiles, consisting of one hundred and sixty specimens, made by Dr. E. W. Nelson and A. E. Goldman in the course of the Lower Californian explorations of the Bureau of Biological Survey, for study in connection with the Albatross material. My heartiest thanks are due to Dr. Leonhard Stejneger, Head Curator of Biology, for information on other specimens in his charge and for many courtesies in connection with this loan. The specimens from this collection have been listed in a separate paragraph in the discussion of the species. Valuable specimens loaned by the Museum of Vertebrate Zoölogy of the University of California and by the Academy of Natural Sciences of Philadelphia, chiefly in connection with other studies, have been drawn upon to some extent in the preparation of the present paper, and my thanks are due to these institutions.

I am greatly indebted to Mr. Charles L. Camp for important suggestions and corrections drawn from his intimate knowledge of Californian herpetology. Miss M. C. Barnett has assisted in many details of the manuscript and bibliography.

It was the purpose of Miss Mary C. Dickerson to follow her paper on the new species of the Albatross collection with a more detailed study of the lizard fauna of the southwestern United States in which the Lower Californian fauna was to be included. I originally hoped to be able to extract from her manuscript, which has been in my hands, an account of the reptiles of the Albatross collection; but I find myself so frequently at variance with her conclusions on the taxonomy of the fauna concerned that it has seemed preferable to drop the plan of editing her work and present an entirely independent paper. Many of the illustrations in the present paper, however, were prepared under Miss Dickerson's direction, and much bibliographical work was done under her direction by Dr. W. B. Veazie.

For the adequate study of the herpetological collections of the Albatross Expedition, it has been necessary to consider the fauna of the whole peninsula and adjacent islands. The 'Herpetology of Lower California'

by Van Denburgh, published in 1895, with numerous subsequent papers by the same author, and especially the recent papers by Van Denburgh and Slevin on the unrivalled Lower Californian collections of the California Academy of Sciences, form an excellent introduction to this fauna, greatly facilitating systematic work, and I have had constant reference to them in the course of the work on the present paper. Several points have been cleared up by correspondence with Dr. Van Denburgh and by reference to specimens received in exchange from the California Academy of Sciences. In order to make clear the cases in which I have differed from these authors, and especially to corroborate or place definitively in the synonymy the species proposed by Dickerson, I have given a new "complete list" of the species recognized. As I have been compelled to make preliminary revisions of several genera concerned, I have included keys to the peninsular species of the remaining genera and have prefixed artificial keys to the genera, in the hope of increasing the usefulness of the paper to amateurs and especially to students of other departments of science who may have occasion or opportunity to deal with the herpetological fauna of Lower California. Too large a proportion of the species in the Lower Californian fauna are unrepresented in the material available to me for study at the present time to warrant a more complete account. I have not included the geographically unrelated Tres Marias Islands off the west coast of Mexico, but have included the reptiles found in the Revilla Gigedo Islands, following the limits of the 'Check List of North American Amphibians and Reptiles,' Stejneger and Barbour, 1917. This extremely useful list has been constantly at hand. As it establishes the nomenclature of the North American species more satisfactorily than any other authority, I have included a reference to it under each species and, in all cases in which I have not followed its nomenclature, I have quoted the authority made use of or have stated my own reasons for such divergence.

The recent monograph of Lower California by Dr. Edward W. Nelson, Chief of the Bureau of Biological Survey, U. S. Dept. of Agriculture (1921, Mem. Nat. Acad. Sci., XVI, pp. 1–194, Pls. I–XXXV) describes the physical conditions of the peninsula of Lower California, illustrates the character of every part of the peninsula in a fine series of plates, and gives an account of the distribution of its plant and animal life. Unfortunately, no complete account of the amphibians and reptiles subsequent to that of Van Denburgh in 1895 was available for the discussion of the distribution of the reptile fauna in Dr. Nelson's paper, and I have no hesitation, therefore, in presenting a new account of the distribu-

tion of the Lower Californian amphibians and reptiles in the present paper. His important conclusions on the faunal subdivisions and life zones of the peninsula are, of course, independent of his discussion of the reptile fauna. In the present account, I have applied his subdivisions into faunal districts to the more complete and accurate list of the reptiles now available.

List of New Forms Proposed in the Present Paper

	Type Locality
Crotaphytus dickersonæ	Tiburon Island
Phrynosoma nelsoni	San Quintin
Phrynosoma jamesi	San Bartolome Bay
Crotalus atrox elegans	Angel de la Guardia Island
Crotalus goldmani	El Piñon

List of New Forms in the Albatross Collection, 1911[1]

(Described by Dickerson, 1919,[2] and below)

New Genus

Sator Dickerson; type, *S. grandævus.*

New Species and Subspecies	Type Locality
Sauromalus townsendi Dickerson	Tiburon Island
Sauromalus varius Dickerson	San Esteban Island
Crotaphytus dickersonæ, new species	Tiburon Island
Callisaurus ventralis inusitatus Dickerson	Tiburon Island
Callisaurus splendidus Dickerson	Angel de la Guardia Island
Sceloporus lineatulus Dickerson	Sta. Catalina Island
Sator angustus Dickerson	Sta. Cruz Island
Sator grandævus Dickerson	Ceralvo Island
Uta concinna Dickerson	Cedros Island
Uta squamata Dickerson	Sta. Catalina Island
Phrynosoma jamesi, new species	San Bartolome Bay
Cnemidophorus celeripes Dickerson	San José Island
Cnemidophorus disparilis Dickerson	Tiburon Island
Cnemidophorus estebanensis Dickerson	San Esteban Island
Cnemidophorus punctilinealis Dickerson	Tiburon Island
Cnemidophorus bartolomas Dickerson	San Bartolome Bay
Cnemidophorus vandenburghi Dickerson	Carmen Island
Verticaria cærulea Dickerson	Carmen Island
Crotalus atrox elegans, new subspecies	Angel de la Guardia Island

[1]The United States National Museum numbers assigned to the types from the Albatross collection will be found in the text of the present paper.

[2]*Ctenosaura insulana, C. conspicuosa, Sauromalus interbrachialis, Callisaurus carmenensis, C. plasticus, Uta mannophorus,* and *U. parva* described by Dickerson in 1919 are referred to synonymy in the present paper.

GEOGRAPHIC ANALYSIS OF THE FAUNA

The herpetological fauna of Lower California is relatively well known and the number of species which further search may be expected to add to the list, aside from insular forms, is probably small. Nevertheless, a serious gap in our knowledge of the distribution of the amphibians and reptiles is the inadequacy of the collections from the middle of the peninsula. Only one considerable collection comes from this area, that made by Diguet and reported on by Mocquard (1899, p. 297, ff.), although Van Denburgh records a few specimens from San Ignacio, Comondu, and San Xavier. Unfortunately, the material available to Mocquard was not critically examined and many of his identifications are uncertain. I need only cite *Chrysemys elegans, Uta stansburiana*, and *Cnemidophorus grahamii* listed by him, to indicate this uncertainty. *Holbrookia propinqua* is recorded by him from Santa Rosalia; but the genus is almost certainly absent from Lower California. The most important contributions to Lower Californian herpetology which remain to be made are a thorough exploration of this central part of the peninsula, to determine the southern limit of the distribution of the northern forms and the northern limits of the San Lucan fauna, and further studies of the northeastern corner of the peninsula, where a number of additions to the fauna may be expected from its close relations with the Colorado Desert. It is possible to give a general review of the fauna, but the limits of the ranges of the majority of the species are still undefined in one direction or another. The chief defect of the present review is the absence of complete and accurate data bearing on the habitat associations of the species concerned.

An investigation of the herpetology of the State of Sonora on the east side of the Gulf of California could not fail to add greatly to our understanding to the origin and relations of the Lower Californian reptile fauna.

The general conclusion of all who have dealt with the Sonoran reptile fauna is that the Lower Californian fauna in its main features is directly derived from the areas to the north. This conclusion I can fully confirm.

The Lower Californian herpetological fauna as listed below contains 149 species and subspecies, 11 amphibians and 138 reptiles, the latter composed of 90 lizards, 47 snakes and one turtle. Of this number, 39 lizards and 7 snakes are insular species, not found on the peninsula, leaving a total of 92 species of reptiles at present known from the peninsula of Lower California.

With the exception of the genus *Sator*, all of the insular forms are more or less directly allied to those of the peninsula or the Mexican mainland. The faunæ of the individual islands are considered below. *Sator* appears to be a relict form, its survival on two islands (Ceralvo and Santa Cruz) being a fairly conclusive proof of its former presence on the peninsula, probably as a distinct form. Its relations are with a generalized *Uta* and with *Sceloporus utiformis* of western Mexico.

Of the amphibians, all the genera and species have a fairly wide range outside and to the north of Lower California, with the exception of the insular *Batrachoseps leucopus*. *Aneides* is not yet known from the mainland of the peninsula, but may be expected in the northwestern corner as it reaches the Coronados Islands. *Plethodon croceater* is probably confined to this area also, Cope's statement (1889, p. 151) that he has seen a specimen from Cape San Lucas being unverified and improbable. *Rana aurora draytonii*, *Scaphiopus hammondii*, and *Bufo boreas halophilus* belong to this northwestern fauna and do not range far to the south in Lower California. *Hyla arenicolor* is known in Lower California only from Ensenada. Four species remain which range throughout the peninsula but with very discontinuous distribution, occurring where suitable habitat conditions exist: *Batrachoseps attenuatus*, *Scaphiopus couchii*, *Bufo punctatus*, and *Hyla regilla*. *Batrachoseps* and *Hyla* are members of the Pacific fauna, not present in the Sonoran subregion, and the *Scaphiopus* and *Bufo* are Sonoran forms, absent from the Pacific subregion. The origin of this mixture of faunæ will be considered below.

The genera of lizards (exclusive of the insular *Sator*) found in Lower California are the following.

Phyllodactylus	*Uta*
Coleonyx	*Phrynosoma*
Ctenosaura	*Gerrhonotus*
Dipso-saurus	*Anniella*
Crotaphytus	*Xantusia*
Sauromalus	*Cnemidophorus*
Callisaurus	*Verticaria*
Uma	*Plestiodon*
Sceloporus	*Bipes*

Of these, *Phyllodactylus*, *Ctenosaura*, and *Bipes* are of Mexican affinity, each with a distinct species in Lower California absent from northern Lower California, while *Phyllodactylus tuberculosus* is identical on the peninsula and in west Mexico. *Uma* enters the peninsula only in the northeastern area, which is continuous with the Colorado Desert. *Coleonyx* also, although ranging farther south on the Gulf side of the

peninsula, may be considered as directly derived from the Colorado Desert. *Anniella* enters the peninsula only a short distance on the Pacific side. The remaining twelve genera reach the southern part of the peninsula. *Verticaria* is nearly confined to Lower California, ranging to the north only a short distance into the San Diegan area. Of the remaining eleven genera, *Dipso-saurus, Sauromalus* and *Callisaurus* form a group whose distribution is very similar, ranging through the whole of Lower California except the northwestern part, the Colorado and Mohave deserts in California, southern Nevada, extreme southwestern Utah, and southwestern Arizona, entering Sonora probably in the desert areas bordering the Gulf of California. *Xantusia*, with a restricted distribution in California, is represented by a distinct species (*X. gilberti*) in southern Lower California, by one in the San Diegan area (*X. henshawi*, not yet recorded from Lower California), and by one in the Mohave Desert (*X. vigilis*) which enters northeastern Lower California. *X. gilberti* appears to be most closely related to the Mohave Desert species.

The remaining genera have a wide distribution in North America. Of *Crotaphytus*, only the widely distributed *C. wislizenii* reaches southern Lower California. The Lower Californian *Plestiodon* is scarcely distinct from the northern *P. skiltonianus*, which is a Pacific form. *Gerrhonotus* has a distinct species in southern Lower California and one in the San Diegan area, while it is also absent from the Colorado Desert, reappearing on the Mexican plateau. *Sceloporus, Uta, Phrynosoma*, and *Cnemidophorus*, each with several species in the peninsula and others on the adjacent islands, are the best developed genera in the fauna of Lower California. Each has one or more species confined to the southern part of the peninsula. *Uta* is remarkable for the two species, *Uta thalassina* and *Uta mearnsi*, respectively of the southern and northern half of the peninsula. If *mearnsi* were extinct, *thalassina* could be considered as forming a distinct monotypic genus; but *mearnsi* is so exactly intermediate between *thalassina* and typical *Uta* that it is impossible to place it with either.

The eighteen genera of snakes in Lower California are the following.

Siagonodon	*Rhinocheilus*
Lichanura	*Hypsiglena*
Coluber	*Natrix*
Salvadora	*Thamnophis*
Phyllorhynchus	*Sonora*
Elaphe	*Chilomeniscus*
Arizona	*Tantilla*
Pituophis	*Trimorphodon*
Lampropeltis	*Crotalus*

Of these, the water snake *Natrix* shows especial Mexican relations, the same species occurring in western Mexico and Lower California. *Lichanura, Phyllorhynchus,* and *Chilomeniscus* are nearly confined to the peninsula, but range into southern California and southwestern Arizona at the north. The distribution of *Trimorphodon lyrophanes* appears to be discontinuous, a wide gap separating the records in southern Arizona from the Lower Californian localities, a distribution paralleled by *Phrynosoma solare* among the lizards. The single species of *Elaphe* is also without a representative in either the San Diegan or Colorado Desert faunæ, its nearest relative geographically being west Mexican. The twelve remaining genera are all wide-ranging North American forms. *Thamnophis* enters Lower California from the North and is absent from the southern end of the peninsula, as probably also is *Rhinocheilus.*

The single fresh-water turtle is apparently closely related to the Mexican species, *Pseudemys ornata.*

To repeat, of the thirty-eight genera of reptiles in Lower California, six are absent in the Pacific area and in the Sonoran deserts of the United States, and by their presence in western Mexico, as allied or identical species, suggest a "Mexican element" in the Lower Californian fauna; these genera are *Ctenosaura, Sator, Bipes, Natrix, Elaphe,* and *Pseudemys.* The three last are widespread in North America, and their absence in the Sonoran deserts of the United States is due to absence of suitable habitat conditions. The aquatic forms may have entered the peninsula directly from Mexico, though this is improbable. Their northward range on the coast of Sonora is, unfortunately, not satisfactorily known. *Ctenosaura* is a characteristically Mexican and Central American genus. A species reaches the Arizonan border from Mexico, and it is not impossible that the genus may formerly have ranged farther into the Sonoran deserts to the north and so may have found access to Lower California, where subsequent isolation is shown by the specific distinctness of the west Mexican and Lower Californian forms. *Bipes* and *Sator* I regard as examples of relict distribution, their present restriction being due to the extinction of the intermediate Sonoran forms. The genus of geckos, *Phyllodactylus,* has a characteristically erratic distribution, and not much importance can be ascribed to its presence in both Lower California and Mexico. *P. tuberculosus* has recently been discovered in southern California. Without knowing the relations of *Elaphe rosaliæ* within the genus, it is impossible to form an opinion as to its geographic relations. It is not improbable that it belongs with *Ctenosaura* in the history of its distribution. The range of certain other

genera and species suggests a different and somewhat earlier stage in this distributional process, *Trimorphodon lyrophanes* and *Phrynosoma solare* being the best examples (see below).

Nelson (*loc. cit.*, p. 117, Pl. xxxi) finds a division of the peninsula into faunal districts, independent of the "life zones," useful in discussing the fauna. The extent of his divisions is shown in the accompanying copy of his map (Fig. 1). The San Diegan, the San Pedro Martir, and the Colorado Desert districts at the north are continuous with faunally similar areas in California. The Cape district, occupying nearly the southern half of the peninsula, has by far the most distinct fauna. The Vizcaino Desert, intermediate in position between the Colorado Desert and San Diegan districts at the north and the Cape district at the south, has an intermediate fauna, with a number of peculiar forms. In the northward extension of the San Lucas fauna to nearly the middle of the peninsula and the adoption of an intermediate district, these faunal subdivisions appear to present a distinct advance. Their agreement with the distribution of the herpetological fauna can now be examined in detail.

The San Pedro Martir district of Nelson, coinciding very nearly with the transitional zone, is characterized herpetologically by the extreme poverty of its fauna. *Sceloporus graciosus vandenburgianus* appears to be confined to this area in Lower California, but otherwise it is scarcely more than an impoverished appendage of the San Diegan fauna. This area is therefore united with the San Diegan for the present discussion.

The San Diegan and San Pedro Martir faunæ, so far as recorded from Lower California, consist of the following forty-three species.

Amphibians

Plethodon croceater
Aneides lugubris lugubris
Batrachoseps attenuatus
Batrachoseps leucopus
Scaphiopus hammondii
Bufo boreas halophilus
Hyla regilla
Hyla arenicolor
Rana aurora draytonii

Reptiles

Crotaphytus wislizenii
Callisaurus ventralis gabbii
Sceloporus occidentalis bi-seriatus
**Sceloporus graciosus vandenburgianus*
**Sceloporus rufidorsum*
**Sceloporus orcutti*
**Uta mearnsi?*
**Lichanura roseofusca*
Coluber flagellum piceus
Coluber lateralis
Salvadora hexalepis
Arizona elegans
Pituophis catenifer rutilus
**Pituophis catenifer annectens*

*Species confined, or nearly so, to the area discussed.

Fig. 1. Map showing the subordinate faunal districts in Lower California, from Nelson (1921, Plate xxxi).

**Uta stansburiana hesperis*
Uta microscutata
**Phrynosoma blainvillii blainvillii*
**Phrynosoma nelsoni*
**Gerrhonotus scincicauda webbii*
**Anniella pulchra*
**Cnemidophorus tessellatus stejnegeri*
**Verticaria hyperythra beldingi*
Verticaria hyperythra schmidti
Plestiodon skiltonianus
Diadophis amabilis
Lampropeltis getulus boylii
**Lampropeltis californiæ californiæ*
Rhinocheilus lecontei
Hypsiglena ochrorhynchus ochrorhynchus
Thamnophis ordinoides vagrans
**Thamnophis ordinoides hammondii*
Crotalus oreganus
**Crotalus exsul*
**Crotalus goldmani*

Of the amphibians, only *Hyla regilla* and *Batrachoseps attenuatus* range to the south of this area; *Hyla arenicolor* reappears in the mountains of Arizona, but is absent in the Colorado Desert proper, as is the wide ranging *Scaphiopus hammondii*. *Batrachoseps leucopus* is confined to the Coronados Islands. The remaining four species are all typical members of the Pacific fauna which reach their southern limits in the San Diegan district.

The reptile fauna is much more heterogeneous. A number of species have a wide range to the north or south of the San Diegan district proper, such as *Sceloporus occidentalis bi-seriatus, Uta microscutata, Verticaria hyperythra schmidti, Plestiodon skiltonianus, Coluber lateralis, Diadophis amabilis, Lampropeltis getulus boylii, Rhinocheilus lecontei, Hypsiglena ochrorhynchus ochrorhynchus, Thamnophis ordinoides vagrans,* and *Crotalus oreganus*. Of these, *Uta microscutata* and *Verticaria hyperythra schmidti* do not range to the north of the area, and *Sceloporus occidentalis bi-seriatus, Thamnophis ordinoides vagrans,* and *Crotalus oreganus* do not range south of it. A number of species range south to Cedros Island: *Sceloporus rufidorsum, Uta stansburiana hesperis* (to San Bartolome Bay), *Verticaria hyperythra beldingi,* and *Crotalus exsul*. A few forms cross over from the Colorado Desert: *Crotaphytus wislizenii, Callisaurus ventralis gabbii, Coluber flagellum piceus, Salvadora hexalepis, Pituophis catenifer rutilus,* and *Arizona elegans*.

The seventeen species of reptiles starred in the list above may be considered characteristic of the San Diegan fauna. *Phrynosoma nelsoni,* however, known only from San Quintin, may prove to be more properly a Vizcaino Desert form. This includes the four species which range south to Cedros Island; and *Uta stansburiana hesperis, Gerrhonotus scincicauda webbii, Anniella pulchra* and *Lichanura roseofusca* range slightly outside the limits of the San Diegan district to the north. *Xantusia henshawi* may be named as a characteristic San Diegan form not yet recorded from

*Species confined, or nearly so, to the area discussed.

Lower California, and *Clemmys marmorata* is a wide ranging Pacific form which may be expected in the San Diegan area in Lower California. *Uta mearnsi* is included in this list, but it seems probable that it is in fact a relict Sonoran form with a unique distribution; it is recorded chiefly from the desert side of the Coast range, and the record from "75 miles southeast of San Diego" is somewhat indefinite.

The Colorado Desert fauna is a highly peculiar one, with two distinctive groups of habitat associations, the desert and the riparian (Grinnell, 1914). In southeastern California, the following amphibians and reptiles are represented.

Amphibians

Bufo cognatus cognatus
Bufo punctatus
Bufo alvarius
Bufo woodhousii
Rana pipiens

Reptiles

Phyllodactylus tuberculatus
Coleonyx variegatus
Dipso-saurus dorsalis dorsalis
Uma notata
Callisaurus ventralis gabbii
Crotaphytus wislizenii
Crotaphytus collaris baileyi
Sauromalus obesus
Uta mearnsi
Uta stansburiana stejnegeri
Uta ornata symmetrica
Uta graciosa
Sceloporus magister
Phrynosoma platyrhinos
Phrynosoma m'callii
Xantusia vigilis
Cnemidophorus tessellatus tessellatus
Kinosternon sonoriense
Siagonodon humilis
Thamnophis marcianus
Chilomeniscus ephippicus
Sonora occipitalis
Sonora episcopa
Lampropeltis getulus yumensis
Lampropeltis getulus boylii
Phyllorhynchus decurtatus
Salvadora hexalepis
Coluber flagellum piceus
Arizona elegans ?
Pituophis catenifer deserticola
Crotalus mitchellii
Crotalus atrox atrox
Crotalus cerastes
Testudo agassizii

Pituophis catenifer rutilus, *Thamnophis megalops*, and *Chilomeniscus cinctus* may be added to this list from Arizonan records, making forty-two species in the Colorado Desert fauna.

Twenty-two of these species have been recorded from northeastern Lower California as follows: *Coleonyx variegatus*, *Dipso-saurus dorsalis dorsalis*, *Crotaphytus collaris baileyi*, *Uma notata*, *Callisaurus ventralis gabbii*, *Uta mearnsi*, *Uta stansburiana stejnegeri*, *Uta graciosa*, *Uta ornata symmetrica*, *Sceloporus magister*, *Phrynosoma platyrhinos*, *Xantusia vigilis*, *Cnemidophorus tessellatus tessellatus*, *Coluber flagellum piceus*, *Lampropeltis getulus yumensis*, *Pituophis catenifer rutilus*, *Phyllorhynchus decur-*

tatus, Thamnophis megalops, Crotalus atrox atrox, Crotalus mitchellii, and *Crotalus cerastes.* Nine more have been recorded from the Cape district but are as yet unknown from the Colorado Desert district in Lower California: *Bufo punctatus, Phyllodactylus tuberculosus, Crotaphytus wislizenii, Sauromalus obesus, Siagonodon humilis, Chilomeniscus ephippicus, Chilomeniscus cinctus, Sonora episcopa,* and *Salvadora hexalepis.* Eleven species remain unrecorded from this area in Lower California, most of which may be expected as additions to its fauna in the future: *Bufo cognatus cognatus, Bufo alvarius, Bufo woodhousii, Rana pipiens, Phrynosoma m'callii, Thamnophis marcianus, Sonora occipitalis, Lampropeltis getulus boylii, Arizona elegans, Testudo agassizii* and *Kinosternon sonoriense.*

The occurrence of *Xantusia vigilis* at San Matias Pass, where it is associated with a species of tree yucca as in the Mohave Desert, indicates a more or less distinct fauna bordering the Colorado Desert district in Lower California on the eastern slopes of the San Pedro Martir Mountains. The distribution of *Uta mearnsi* has been mentioned above. The peculiar case of *Phrynosoma solare,* which is absent in California and reappears at Las Animas Bay, Lower California, a third of the distance down the Gulf side of the peninsula, seems to indicate a somewhat recent "invasion" of the Colorado Desert into a less arid area. Unfortunately, the eastern escarpment of the Sierra Juarez and San Pedro Martir is so precipitous that there is little hope of tracing a continuous zone through this area.

The Vizcaino Desert district of Nelson's map occupies the area between the three districts just discussed and the Cape district. It should include, in my opinion, the Magdalena Plain. Its fauna is imperfectly known and this area quite certainly offers a most interesting field for further herpetological exploration.

In view of this lack of information, it is not possible to present a list of the amphibians and reptiles of this area. Four species are characteristic of and confined to it, as far as known: *Callisaurus crinitus, Phrynosoma jamesi, Cnemidophorus bartolomas,* and *Cnemidophorus rubidus.*

There is a "crossing over" of the Sonoran desert fauna in this area, cutting off a remnant of the San Diegan fauna on Cedros Island. My inference that the fauna of the Magdalena Plain is to be directly associated with that of the Vizcaino Desert is based primarily on the distribution of *Callisaurus crinitus,* the close relations between *Cnemidophorus rubidus* and *C. bartolomas,* and the presence of *Verticaria hyperythra beldingi.* It would be of great interest to know whether *Cnemidophorus*

bartolomas and *Phrynosoma jamesi* are confined to the Pacific Coast, as appears at present, or to what extent these species range into this district. The occurrence of certain species at La Paz (*Crotaphytus wislizenii*, for example) may indicate a route of migration via the Vizcaino Desert and the Magdalena Plain of the undifferentiated Sonoran elements in the fauna of the Cape district.

The San Lucan fauna is the most characteristic and the most differentiated of the four Lower Californian herpetological faunæ though scarcely more distinct from the Colorado Desert fauna than the latter is from the San Diegan. Five, possibly seven, species of the Vizcaino Desert fauna are distinct from the species of the two northern districts. The Cape district has no less than twenty-nine species strictly confined to it. The total number of species recorded from it is fifty-two, as follows.

Amphibians

Batrachoseps attenuatus
Scaphiopus couchii
Bufo punctatus
Hyla regilla

Reptiles

Phyllodactylus tuberculosus
**Phyllodactylus unctus*
**Ctenosaura hemilopha*
**Dipso-saurus dorsalis lucasensis*
Crotaphytus collaris baileyi
Crotaphytus wislizenii
**Sauromalus ater*
**Callisaurus draconoides*
Callisaurus ventralis gabbii
**Sceloporus zosteromus*
**Sceloporus licki*
**Uta thalassina*
Uta mearnsi
**Uta elegans*
Uta microscutata
**Uta nigricauda*
**Phrynosoma coronatum*
**Gerrhonotus multi-carinatus*
**Xantusia gilberti*
**Cnemidophorus maximus*
**Verticaria hyperythra hyperythra*
Verticaria hyperythra schmidti
Plestiodon skiltonianus
**Bipes biporus*
Siagonodon humilis
**Lichanura trivirgata*
Coluber flagellum piceus
Coluber lateralis
**Coluber aurigulus*
Salvadora hexalepis
Phyllorhynchus decurtatus
**Elaphe rosaliæ*
**Pituophis vertebralis*
**Lampropeltis getulus conjuncta*
**Lampropeltis californiæ nitida*
Rhinocheilus lecontei
Hypsiglena ochrorhynchus ochrorhynchus
Natrix valida
Sonora episcopa
**Chilomeniscus stramineus*
**Chilomeniscus punctatissimus*
Chilomeniscus cinctus
**Tantilla planiceps*
Trimophodon lyrophanes
**Crotalus atrox lucasensis*
**Crotalus enyo*
**Crotalus mitchellii*
**Pseudemys ornata nebulosa*

The species starred are confined to this area. The degree of peculiarity is much increased if the insular species are included. Since most of these simply represent peninsular forms, I have not included them in

the discussion; but the two insular species of *Sator*, which is not represented on the peninsula, may be mentioned in this connection, especially as *Sator* is the only genus of reptiles entirely confined to Lower California (cf. *Verticaria*, etc., above).

Of the species occurring outside the Cape district, only *Natrix valida* and possibly *Gerrhonotus multi-carinata* (cf. Stejneger and Barbour, 1917, p. 61) are West Mexican and not found in northern Lower California, although *Ctenosaura hemilopha*, *Bipes biporus*, and possibly *Elaphe rosaliæ* are most closely allied to West Mexican forms at present. The relations of the San Lucan fauna with the San Diegan and the Colorado Desert faunæ are very unequal.

Of the fifty-two species, fifteen occur also in the Colorado Desert fauna and seven more are obviously closely allied to Colorado Desert forms; ten are identical with San Diegan forms, but of these, two are found also in the desert; while five more species are more closely allied to San Diegan forms than to desert forms; the proportion of Colorado Desert element to San Diegan element is therefore about 22 to 13. The San Lucan forms in the San Diegan district, however, appear to be largely derived forms, as with the exception of *Hyla regilla*, *Plestiodon skiltonianus*, and *Rhinocheilus lecontei*, these find their northern limit in this area, while the San Lucan forms which reach the desert for the most part (generically if not specifically) have a wide range. This I have shown more fully above in discussing generic ranges.

San Lucan Species Occurring in the Colorado Desert or Allied Sonoran Faunæ

(*a*). As Identical Species

Scaphiopus couchii	*Siagonodon humilis*
Bufo punctatus	*Coluber flagellum piceus*
Phyllodactylus tuberculosus	*Salvadora hexalepis*
Crotaphytus collaris baileyi	*Phyllorhynchus decurtatus*
Crotaphytus wislizenii	*Sonora episcopa*
Callisaurus ventralis gabbii	*Chilomeniscus cinctus*
Uta mearnsi	*Trimorphodon lyrophanes*
	Crotalus mitchellii

(*b*). As Related Species

San Lucan	Colorado Desert
Dipso-saurus dorsalis lucasensis	*Dipso-saurus dorsalis dorsalis*
Sauromalus ater	*Sauromalus obesus*
Sceloporus zosteromus	*Sceloporus magister*
Uta elegans	*Uta stansburiana stejnegeri*
Xantusia gilberti	*Xantusia vigilis*
Tantilla planiceps	*Tantilla nigriceps*
Crotalus atrox lucasensis	*Crotalus atrox atrox*

San Lucan Species Occurring in the San Diegan Fauna

(*a*). As Identical Species

Batrachoseps attenuatus	*Plestiodon skiltonianus*
Hyla regilla	*Coluber lateralis*
Uta microscutata	*Rhinocheilus lecontei*
Verticaria hyperythra schmidti	*Hypsiglena ochrorhynchus ochrorhynchus*

(*b*). As Related Species

San Lucan	San Diegan
Sceloporus licki	*Sceloporus occidentalis bi-seriatus*
Gerrhonotus multi-carinatus	*Gerrhonotus scincicauda webbii*
Lichanura trivirgata	*Lichanura roseofusca*
Lampropeltis getulus conjuncta	*Lampropeltis getulus boylii*
Lampropeltis californiæ nitida	*Lampropeltis californiæ californiæ*

As there are no important additions to be made to the faunæ of the Revilla Gigedo Islands and islands off the Pacific coast of Lower California, with the exception of Cedros Island, they may be omitted from the present résumé. Van Denburgh and Slevin (1914) have given a complete account of these insular faunæ.

The fauna of Cedros at present known consists of eleven species:

Hyla regilla	*Verticaria hyperythra beldingi*
Crotaphytus wislizenii	**Cnemidophorus multiscutatus*
**Uta concinna*	**Cnemidophorus labialis*
Sceloporus rufidorsum	*Siagonodon humilis*
**Phrynosoma cerroense*	*Crotalus exsul*
**Phrynosoma schmidti*	

The five species starred are peculiar to the island. *Hyla regilla, Sceloporus rufidorsum,* the *Verticaria,* and *Crotalus exsul* are San Diegan forms reaching Cedros. It is not impossible that they are cut off by a considerable gap from their nearest mainland occurrence, as the *Crotaphytus* and *Siagonodon* apparently represent an invasion of the desert forms. The relations of the peculiar forms are not fully established, but it seems certain that *Uta concinna* and *Cnemidophorus multiscutatus* are most closely allied to San Diegan forms, while the remaining three are representatives of the adjacent Vizcaino Desert fauna.

The islands of the Gulf of California appear to fall simply enough into two groups, those nearest the peninsula having a non-Mexican and strictly Lower Californian fauna, while those nearer the mainland have a fauna derived from Mexico.

The fauna of the island of Angel de la Guardia consists of the following seven forms:

**Sauromalus hispidus*
**Crotaphytus insularis*
**Callisaurus splendidus*
Uta stansburiana stejnegeri
**Cnemidophorus dickersonæ* (Isla Partida)
**Crotalus atrox elegans*
Crotalus mitchellii

Of these, the five starred are peculiar to the island. As far as our present knowledge of these species goes, they are equally related to Lower Californian and West Mexican representatives.

From Sal Si Puedes Island, only one species, *Cnemidophorus canus*, is known.

A single species, *Crotalus tortugensis*, is known from the island of Tortuga.

From San Marcos Island, only *Verticaria hyperythra schmidti* is known, a form widely distributed on the peninsula.

Five species are known from Carmen Island:

Callisaurus ventralis gabbii
Uta elegans
Uta microscutata
**Verticaria cærulea*
**Cnemidophorus vandenburghi*

Of these, the two last are peculiar to the island; the other three are found on the adjacent shores of the peninsula. *Verticaria cærulea* is interesting as an insular representative of the more plastic peninsular form, *Verticaria hyperythra schmidti*.

From Monserrate Island, only two species, *Sceloporus monserratensis* and *Verticaria picta*, are known.

Five species are known from Santa Catalina Island:

Dipso-saurus dorsalis lucasensis
**Sceloporus lineatulus*
**Uta squamata*
**Cnemidophorus catalinensis*
**Lampropeltis catalinensis*

The peculiar species of *Sceloporus* differs very slightly from the mainland form, while the *Uta*, *Cnemidophorus*, and *Lampropeltis* are much more distinct from their peninsular allies.

Only a single highly peculiar species, *Sator angustus*, is known from Santa Cruz Island.

Six species are now known from San José Island:

Callisaurus ventralis gabbii
Sceloporus zosteromus
Uta elegans
Uta microscutata
**Cnemidophorus celeripes*
**Verticaria sericea*

The latter two are peculiar to the island, the *Verticaria* being most closely allied to the species on Carmen Island, while the similarity to the Carmen Island fauna is increased by the species in common with it and the peninsula.

San Francisco Island has a single peculiar species, *Verticaria franciscensis.*

The fauna of Espiritu Santo Island comprises seven species:

Sauromalus ater
Uta elegans
Sceloporus zosteromus
Sceloporus licki
**Verticaria espiritensis*
Chilomeniscus punctatissimus
**Coluber barbouri*

The peculiar species of snake is, I believe, more closely related to the mainland form from which it is obviously derived than is the case with the species peculiar to other islands.

From Ceralvo Island, three species are known, *Verticaria ceralbensis, Sator grandævus*, and *Ctenosaura hemilopha.* The occurrence of a related but highly distinct species of *Sator* on the island of Santa Cruz indicates that this genus was formerly present on the peninsula, while the divergence shown by these two insular species indicates a considerable antiquity for the genus. I am unable to distinguish the *Ctenosaura* from the peninsular species.

Turning to the islands which I believe to be more closely related to the Mexican mainland than to the Lower Californian peninsula, San Esteban Island, in the middle of the gulf, has three species, *Ctenosaura hemilopha, Cnemidophorus estebanensis* and *Crotalus molossus*, at present known from it besides the peculiar *Sauromalus varius.* Of these, the first is found in Lower California, the *Cnemidophorus* is almost identical with the *C. melanostethus* of Sonora, and the *Crotalus* is identical with a Mexican form not found in Lower California. The relations of the *Sauromalus* are not evident. As the question of relations stands, therefore, it is two to one in favor of a Mexican relation of the island. From the soundings of the gulf north and south of San Esteban, it is evident that this is the most probable location of a connection of Lower California with Sonora, if such a connection ever existed.

The species known from Tiburon Island are the following:

**Sauromalus townsendi*
Crotaphytus wislizenii
**Crotaphytus dickersonæ*
**Callisaurus ventralis inusitatus*
**Cnemidophorus punctilinealis*
**Cnemidophorus disparilis*
Micrurus euryxanthus

While five of these are at present known only from the island, it seems probable that they occur on the adjacent coast of Sonora. The appearance of *Micrurus euryxanthus* is a striking evidence of the non-Californian character of the Tiburon fauna.

The two species of lizards known from San Pedro Martir Island, *Uta palmeri* and *Cnemidophorus martyris*, are highly peculiar but the relations of the latter with *C. disparilis* of Tiburon Island lead me to associate this island with the Mexican mainland.

Only two species, *Uta nolascensis* and *Cnemidophorus bacatus*, are known from the island of San Pedro Nolasco.

A large number of species confined to islands in the Gulf of California are now known, the total (to January 1, 1922) being thirty-four, with sixteen islands represented. As no less than fourteen of these are known to me only from the preliminary diagnoses, I am unable to form definite opinions as to their relations. The mere list, however, is instructive:

Crotaphytus dickersonæ
" *insularis*
Sauromalus hispidus
" *townsendi*
" *varius*
Callisaurus splendidus
" *ventralis inusitatus*
Sceloporus lineatulus
" *monserratensis*
Sator angustus
" *grandævus*
Uta palmeri
" *squamata*
" *nolascensis*
Cnemidophorus vandenburghi
" *celeripes*
" *estebanensis*
" *punctilinealis*
Cnemidophorus disparilis
" *martyris*
" *catalinensis*
" *dickersonæ*
" *canus*
" *bacatus*
Verticaria ceralbensis
" *espiritensis*
" *sericea*
" *cærulea*
" *franciscensis*
" *picta*
Coluber barbouri
Lampropeltis catalinensis
Crotalus tortugensis
" *atrox elegans*

There are thirty species of lizards and only four snakes. Of the thirty lizards, sixteen are teiids belonging to the two genera *Cnemidophorus* and *Verticaria*. The ten insular *Cnemidophorus* compare with five peninsular species, the six insular *Verticarias* with three on the peninsula. The great majority of all of the species will certainly be found to be very closely allied to the peninsular or Mexican forms from which they are derived. In contrast to these stands a small number of very distinct forms, such as the species of *Sauromalus*, the *Sators*, and possibly *Verticaria ceralbensis*. The latter group of species I believe to have been differ-

entiated at a much earlier stage than the former, and I regard their present isolation as "relict distribution." They were probably elements of the older Lower Californian fauna co-existing with the earlier and more widely differentiated species of the peninsula, such as *Uta thalassina*, while the less distinct forms have become differentiated since the relatively recent faulting or submergence which has separated the islands from the peninsula.

SPECULATIONS ON THE ORIGIN OF THE FAUNA

The factors in the geologic history of Lower California which seem to bear most directly on the origin of its present fauna are: (1) the ancient (pre-Cretaceous) granitoid character of the southern tip of the peninsula; (2) the extensive Miocene lava-flows of the middle of the peninsula; and (3) the recent (post-Pliocene) submergence of the middle of the peninsula, where marine fossils and beaches are found to a height of over 3000 feet.

Although recent beaches are not recorded from the immediate vicinity of La Paz, the submergence to the north indicates that the hypothesis of Eisen (1895, p. 755) and Nelson (1921, p. 53), that the Cape area south of La Paz has been separated from the peninsula at a relatively recent date, is probably correct. I believe, however, that Nelson is right in regarding this separation as of comparatively little importance in the history of the fauna. The islands which parallel the gulf coast of the peninsula were quite certainly part of the peninsula at a fairly recent date. The topographical similarity of many of the islands with isolated capes and mountains of the adjacent coast is very strikingly illustrated in Nelson's map (*loc. cit.*, Pl. xxxv).

As the bulk of the middle part of the peninsula consists of Miocene deposits with extensive late Miocene lava-flows (Darton, 1921, p. 720, ff.) it is evident that, if there are remnants of a pre-Miocene fauna in Lower California, they must be looked for in the southern tip of the peninsula.

It is possible that the apparently oldest element in the fauna (see below) antedates the Miocene igneus activity. The larger part of the fauna, and that with a more characteristically desert facies, however, must have entered the peninsula from the north subsequent to the late Tertiary volcanic activity. It is possible that another element of the fauna might be dated from the most recent submergence (late Pleistocene) and this probably consists of the Colorado Desert species (such as *Crotaphytus wislizenii, Callisaurus ventralis gabbii, Coluber flagellum*

piceus, and *Salvadora hexalepis*) which reach the Cape area without having been differentiated from the northern stock.

The Lower Californian amphibians and reptiles are accordingly divisible into groups or "faunal elements" which seem to represent successive invasions from the continental fauna at the north. These may be arranged in a very tentative order as shown in the accompanying table.

I. The "Mexican" forms	Middle or Pre-Miocene	Early Tertiary immigration
Extensive Destruction of Fauna by Igneus Activity		
II. The forms in common with the San Diegan area and Mexican Plateau	Post-Miocene and Pliocene	Late Tertiary and Pleistocene immigration
III. The forms bordering the Colorado Desert		
IV. The Colorado Desert forms which have become differentiated in the Cape area	Pleistocene	
Last Extensive Submergence		
V. The Colorado Desert forms which reach the Cape unchanged	Subsequent to the last submergence	Recent immigration *in process*
VI. The desert forms which have not yet spread beyond the borders of the Colorado Desert proper	Contemporary	

The most important consideration bearing on the history of the Lower Californian fauna is the discontinuity of the ranges of numerous genera and species at the Colorado Desert to the north, which appears to be inserted like a wedge separating closely related forms in Arizona and Lower California. It may be supposed that an increasing aridity in this area during Pleistocene and post-glacial time has led to the evolution of forms specifically adapted to desert conditions in this area, their ancestors, where they continue, being forced to follow their migrating

habitat, both through their lack of adaptation to the increasing aridity and through the pressure exerted on them by their better adapted derivatives. This accordingly parallels on a small scale the large-scale process of climatic evolution of faunæ elaborated by Matthew (1915). On the theory that this has been a long-continued and fairly uniform process, the composite character of the fauna may be quite simply explained. The numerous species confined to the Colorado Desert proper and extending only into the northeastern part of Lower California represent the most recent faunal development, i.e., are the most recent element in the Lower Californian fauna. The only genus peculiar to this fauna is *Uma*, which is closely restricted in habitat. A slightly older element consists of the genera confined to the Colorado and adjacent desert areas, which reach southern Lower California; these are *Dipso-saurus*, *Sauromalus*, *Callisaurus*, *Phyllorhynchus*, and *Chilomeniscus*. With the exception of *Phyllorhynchus*, they have developed a distinct species in the Cape district. The desert species which range into southern Lower California without differentiation may represent the intermediate stage between these two elements. A "highway" for their immigration seems to be present in the Vizcaino Deserts and the Magdalena Plain. Correlated with the development and spread of this strictly desert fauna is the distribution of the species which in some sense border the desert. *Scaphiopus couchii*, *Hyla arenicolor*, *Phrynosoma solare*, *Rhinocheilus lecontei*, *Hypsiglena ochrorhynchus ochrorhynchus*, and *Trimorphodon lyrophanes*, which are apparently absent from the Colorado Desert but present in Lower California, reappear in Arizona at the border of the Mexican Highland (Physiographic nomenclature of Fenneman, 1916, p. 34). *Natrix valida*, which probably ranges into the State of Sonora in Mexico, may be included with this list, and, somewhat more doubtfully, the fresh-water turtle, *Pseudemys ornata nebulosa*, which is subspecifically distinct in Lower California. A number of other species which border the Colorado Desert on one side only are in full accord with the distribution of the above, *Uta mearnsi*, *Xantusia vigilis*, and *Lichanura roseofusca*, being examples. In the light of the discontinuity of the ranges of the foregoing list of species, it seems logical to interpret the oldest element in the fauna in the same way. This element consists of genera absent in the strictly desert areas to the north but present in the Cape district or the San Diegan district and reappearing in southern Arizona or farther south in Mexico, such as *Gerrhonotus*, *Ctenosaura*, *Plestiodon*, *Bipes*, *Elaphe*, and *Tantilla*. The section of the genus *Uta* with an entire frontal (*Uta nigricauda* and *microscutata*) belongs here, and probably the

genus *Sator*, now entirely restricted to islands in the Gulf of California. *Uta thalassina*, restricted to southern Lower California, also may be placed with this "older" element. Finally, the species common to the Cape district and the San Diegan district are believed to represent a radiating migration antedating the present conditions, as it is difficult to see how migration from the relatively humid San Diegan area to the restricted similar areas in the Cape district could take place at present, on account of the intervening deserts. It must therefore be supposed that a continuous, or nearly continuous, semi-humid belt connected the San Diegan and the Cape areas at an early date. It is not incompatible with this theory that, in the diverse habitat conditions of Lower California and its isolated position, a large number of species have developed "in place." This differentiation after migration accounts in part for the distinctive species of the various faunal districts.

ARTIFICIAL KEYS TO THE GENERA OF AMPHIBIANS AND REPTILES IN LOWER CALIFORNIA

The amphibians are scantily represented in Lower California by eleven species of seven genera, which may be recognized as follows:

1. Adult tailed ..... 2.
   Adult tailless ..... 4.
2. Toes four in front, five behind ..... 3.
   Toes four on each foot ..... *Batrachoseps.*
3. Tail longer than head and body; size large, adult exceeding 10 inches . . *Plethodon.*
   Tail shorter than head and body; size smaller, adult rarely exceeding 6 inches. *Aneides.*
4. Digits dilated at the tip ..... *Hyla.*
   Digits not dilated ..... 5.
5. Skin smooth ..... *Rana.*
   Skin more or less warty ..... 6.
6. Two metatarsal tubercles, not black or horny ..... *Bufo.*
   A single (inner) metatarsal tubercle with a black and horny edge . . *Scaphiopus.*

The two species of *Hyla* may be distinguished as follows:

Skin rough, with small warts; two phalanges of fourth toe free from web. *H. arenicolor*
Skin smooth, three phalanges of fourth toe free from web ..... *H. regilla*

The two species of *Bufo* do not occur in the same area; they are very different in form, the *Bufo boreas halophilus* in the northwestern part of the peninsula being a large species with a deep head, the *Bufo punctatus* from the cape region much smaller, with a flattened head.

The species of *Scaphiopus* in Lower California may be distinguished as follows:

Snout sharply truncate in profile ..... *S. hammondii.*
Snout rounded in profile ..... *S. couchii.*

The reptiles of Lower California include lizards, snakes and a single species of non-marine turtle. The lizards represent nine families: Gekkonidæ, Eublepharidæ, Iguanidæ, Anguidæ, Anniellidæ, Xantusiidæ, Teiidæ, Scincidæ, and Amphisbænidæ. The snakes represent four families: Leptotyphlopidæ, Boidæ, Colubridæ and Viperidæ. These families may be distinguished as follows:

1. Both pairs of limbs present ..... 2.
   Only one pair of limbs, or none ..... 8.
2. Eyelids absent ..... 3.
   Eyelids developed ..... 4.
3. Top of head covered with small granular scales; tips of digits dilated with a pair of plates beneath ..... Gekkonidæ.
   (a single genus in Lower California, *Phyolldactylus*).
   Top of head with large plates; tips of digits not dilated ..... Xantusiidæ.
   (a single genus in Lower California, *Xantusia*).
4. Top of head covered with very small granular scales, skin free from skull, pupil vertical ..... Eublepharidæ.
   (a single genus in Lower California, *Coleonyx*)
   Top of head covered with scales larger than those of the back, skin not free from skull ..... 5.
5. A series of femoral pores ..... 6.
   No femoral pores ..... 7.
6. Ventral scales in regular transverse and longitudinal series ..... Teiidæ.
   (see key below).
   Ventral scales not in regular series, more numerous ..... Iguanidæ.
   (see key below).
7. Dorsal scales smooth, laterals and ventrals not much different ..... Scincidæ.
   (a single genus in Lower California, *Plestiodon*).
   Dorsal scales keeled, lateral scales smaller than dorsals or ventrals, a strong lateral fold ..... Anguidæ.
   (a single genus in Lower California, *Gerrhonotus*).
8. A pair of anterior limbs, no posterior pair ..... Amphisbænidæ.
   (a single genus in Lower California, *Bipes*, forming a distinct subfamily (Bipedinæ) of this otherwise limbless family).
   No anterior or posterior limbs ..... 9.
9. Scales of the lower surface not enlarged ..... 10.
   Ventral scales enlarged ..... 11.
10. Eyes present, external ..... Anniellidæ.
    (a single genus in Lower California, *Anniella*).
    Eyes absent externally, visible as a black dot beneath the scales which cover them ..... Leptotyphlopidæ.
    (a single genus in Lower California, *Siagonodon*).

11. A pair of spurs just in front of the anal cleft, (representing the vestigial hind limbs); scales of top of head small.....Boidæ.
(a single genus in Lower California, *Lichanura*).
No spurs in front of anal cleft.....12.
12. A pair of large erectile fangs in the upper jaw.....Viperidæ.
(a single genus in Lower California, *Crotalus*).
No erectile fangs in the upper jaw.....Colubridæ.
(see key below).

Key to the Genera of Teiidæ in Lower California

Two frontoparietal plates.....*Cnemidophorus.*
A single frontoparietal plate.....*Verticaria.*

Key to the Genera of Iguanidæ in Lower California

1. A dorsal crest.....2.
No dorsal crest.....3.
2. Tail spinous at base.....*Ctenosaura.*
Tail not spinous at base.....*Dipso-saurus.*
3. Head with strong spines or horns.....*Phrynosoma.*
Head without horns.....4.
4. Supraciliary scales juxtaposed; size large; form stout.....*Sauromalus.*
Supraciliary scales strongly imbricate; form slender.....5.
5. Upper labials oblique, imbricate.....6.
Upper labials not oblique or imbricate.....7.
6. Back with an ocellated color pattern; two rows of subdigital scales; a series of very long lateral fringes on the digits.....*Uma.*
Back without ocellation; a single row of subdigital scales; fringes present in one species.....*Callisaurus.*
7. Head covered with small irregular scales; no large occipital scale..*Crotaphytus.*
Head scales enlarged, a large occipital.....8.
8. A well-defined collar, preceded by a transverse gular fold.....*Uta.*
No collar.....9.
9. A well-defined transverse gular fold; body compressed; tail very long..*Sator.*
No transverse gular fold; body usually depressed.....*Sceloporus.*

Key to the Genera of Colubrine Snakes in Lower California

1. Scales keeled.....2.
Scales smooth.....4.
2. The two prefrontal plates longitudinally divided, forming four prefrontals. *Pituophis.*
Only two prefrontal plates.....3.
3. Anal plate simple.....*Thamnophis.*
Anal plate divided.....*Natrix.*
4. Anal entire.....5.
Anal divided.....8.
5. Loreal scales 2–4; rostral projecting.....*Phyllorhynchus.*
One loreal; rostral not projecting.....6.

6. Subcaudal scales usually undivided ..... *Rhinocheilus.*
   Subcaudal scales in two rows ..... 7.
7. Dorsal scales 27–31 ..... *Arizona.*
   Dorsal scales less than 27 ..... *Lampropeltis.*
8. Loreal absent ..... 9.
   Loreal present ..... 10.
9. Nasal fused with the frontonasal plate ..... *Chilomeniscus.*
   Nasal not fused with the frontonasal ..... *Tantilla.*
10. Two loreals ..... *Trimorphodon.*
    A single loreal ..... 11.
11. Rostral projecting, its lateral edges free; color pattern of longitudinal bands. *Salvadora.*
    Rostral not projecting; coloration various ..... 12.
12. Dorsal scales in 15 rows ..... *Sonora.*
    Dorsal scales in more than 15 rows ..... 13.
13. Pupil vertical ..... *Hypsiglena.*
    Pupil round ..... 14.
14. Dorsal scales in 17–19 rows ..... *Coluber.*
    Dorsal scales in about 33 rows ..... *Elaphe.*

DISTRIBUTIONAL LIST OF THE AMPHIBIANS AND LAND REPTILES OF LOWER CALIFORNIA AND THE NEIGHBORING ISLANDS, WITH NOTES ON THE SPECIES CONTAINED IN THE COLLECTION MADE BY THE 'ALBATROSS' IN 1911

AMPHIBIA

Caudata

Batrachoseps attenuatus (Eschscholtz)

Salamandrina attenuata Eschscholtz, 1833, p. 1, Pl. xxii, figs. 1–4.
Batrachoseps attenuatus Stejneger and Barbour, 1917, p. 13.

Range.—S. W. Oregon, California, and Lower California.

Lower Californian Records.—La Paz, Lockington, 1880, p. 295; San Pedro Martir Mts., Van Denburgh, 1895*a*, p. 560.

Batrachoseps leucopus Dunn

Batrachoseps leucopus Dunn, 1922, Copeia, No. 109, p. 60.

Range.—Coronados Islands, Lower California.

Plethodon croceater Cope

Plethodon croceater Cope, 1867, p. 210; Stejneger and Barbour, 1917, p. 14.

Range.—Lower California and California north to El Dorado County.

Lower Californian Records.—"75 miles S. E. of San Diego," Lockington, 1880, p. 295; Cape St. Lucas, Cope, 1889, p. 150. (Occurrence doubtful in the Cape district.)

Aneides lugubris lugubris (Hallowell)

Salamandra lugubris Hallowell, 1849, p. 126.

Aneides lugubris lugubris Stejneger and Barbour, 1917, p. 21.

Range.—California; the Coronados Islands.

Lower Californian Records.—Coronados Islands, Van Denburgh and Slevin, 1914, p. 139.

Salientia

Scaphiopus couchii Baird

Scaphiopus couchii Baird, 1854, p. 62; Stejneger and Barbour, 1917, p. 25.

Range.—Texas to Arizona, northern Mexico and Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1863*a*, p. 52; La Paz, Yarrow, 1882, p. 177; San José del Cabo, Miraflores, Van Denburgh, 1895*a*, p. 558; San Ignacio, Mulege, Mocquard, 1899, p. 342; between La Paz and San Pedro, Van Denburgh and Slevin, 1921*a*, p. 53.

Scaphiopus hammondii Baird

Scaphiopus hammondii Baird, 1859*a*, p. 12, Pl. xxviii, fig. 2; Stejneger and Barbour, 1917, p. 25.

Range.—Montana to Mexico, westward to the Pacific Coast and northern Lower California.

Two specimens in the collection of the Biological Survey add this form to the fauna of Lower California. U. S. N. M. No. 37710 is from Ensenada; 37709, without locality, is probably also from the northwestern part of the peninsula.

Bufo punctatus Baird and Girard

Bufo punctatus Baird and Girard, 1852, p. 173; Stejneger and Barbour, 1917, p. 29.

Range.—Western Texas, Utah, southern California, and Lower California.

Lower Californian Records.—La Paz, Yarrow, 1875, p. 162; Cape St. Lucas, Cope, 1889, p. 262; Santa Anita, San Ignacio, Agua Caliente, San José del Cabo, Corral de Piedras (Sierra el Taste), Miraflores, Van Denburgh, 1895*a*, p. 559; Santa Rosalia, Mocquard, 1899, p. 334; San Antonio, San Pedro, foothills of Sierra Laguna, Van Denburgh and Slevin, 1921*a*, p. 53.

This species was secured by the Albatross Expedition at Miraflores, Lower California (A. M. N. H. Nos. 3163, 3165–67, U. S. N. M. No. 64454).

Specimens at hand from the Biological Survey collection come from Santa Anita (U. S. N. M. Nos. 37713–15); Santana (37716); San Ignacio (37717–18); and La Providencia Canyon, east base of San Pedro Martir Mountains (37719–20).

The last of these localities is the most northerly record for this species in Lower California.

Bufo boreas halophilus Baird and Girard

Bufo halophila Baird and Girard, 1853*a*, p. 301.

Bufo boreas halophilus Stejneger and Barbour, 1917, p. 27.

Range.—Western Nevada, California, and northern Lower California.

Lower Californian Records.—Ensenada, Van Denburgh and Slevin, 1921*a*, p. 53.

Two specimens in the collection of the Biological Survey come from La Grulla (U. S. N. M. Nos. 37711–37712).

Hyla arenicolor Cope

Hyla arenicolor Cope, 1866, p. 84; Stejneger and Barbour, 1917, p. 32.

Range.—Utah to Texas and northern Lower California, south in Mexico to Guadalajara and Toluca.

Lower Californian Records.—Ensenada, Van Denburgh and Slevin, 1921*a*, p. 54.

Hyla regilla Baird and Girard

Hyla regilla Baird and Girard, 1852*a*, p. 174; Stejneger and Barbour, 1917, p. 33.

Range.—Vancouver Island and British Columbia to Lower California.

Lower Californian Records.—Cedros Island, Streets, 1877, p. 35; La Paz, Yarrow, 1882, p. 171; Cape St. Lucas, Cope, 1889, p. 360; Sierra Laguna, San Rafael Valley, San Pedro Martir Mt., San Ignacio, Comondu, Miraflores, San José del Cabo, Van Denburgh, 1895*a*, p. 556; Santa Rosalia, Mocquard, 1899, p. 339.

This species was collected on Cedros Island by the Albatross Expedition (A. M. N. H. No. 3161, U. S. N. M. No. 64453).

A specimen from La Grulla (U. S. N. M. No. 37708) was collected by the Biological Survey Expedition.

Rana aurora draytonii Baird and Girard

Rana draytonii Baird and Girard, 1852*a*, p. 174; Stejneger and Barbour, 1917, p. 37.

Rana aurora draytonii Camp, 1917, p. 115.

Range.—Oregon, California and northern Lower California.

Lower Californian Records.—San Pedro Martir Mts., Van Denburgh, 1896, p. 1008.

Three specimens in the collection made by the Biological Survey are from San Tomas (U. S. N. M. No. 37699); La Grulla (37700); and Rancho San Antonio (37701).

Reptilia

Lacertilia

Phyllodactylus tuberculosus Wiegmann

Phyllodactylus tuberculosus Wiegmann, 1835, p. 241, Pl. xviii, figs. 2–2*a*; Stejneger amd Barbour, 1917, p. 42.

RANGE.—Western Mexico, Lower California and extreme southern California.

LOWER CALIFORNIAN RECORDS.—Cape St. Lucas, Cope, 1863, p. 102; La Paz, Yarrow, 1882, p. 73; Santa Rosalia, Mocquard, 1899, p. 300; San Xavier, Bartolo, Van Denburgh and Slevin, 1921*a*, p. 54.

The collection made by the Albatross Expedition contains a single adult specimen (U. S. N. M. No. 64455) from Miraflores.

Phyllodactylus unctus (Cope)

Diplodactylus unctus COPE, 1863, p. 102.
Phyllodactylus unctus STEJNEGER AND BARBOUR, 1917, p. 42.

RANGE.—Lower California.

LOWER CALIFORNIAN RECORDS.—Cape St. Lucas, Cope, 1863, p. 102; Triunfo, Streets, 1877, p. 35; La Paz, Yarrow, 1882, p. 73; San José del Cabo, Miraflores, Van Denburgh, 1895, p. 86; Agua Caliente, Van Denburgh and Slevin, 1921*a*, p. 55.

Key to Distinguish the Species of *Phyllodactylus* in Lower California

Small dorsal granular scales interspersed with large tubercles.....*P. tuberculosus.*
Dorsal scaling uniform.....*P. unctus.*

Coleonyx variegatus (Baird)

Stenodactylus variegatus BAIRD, 1858, p. 254.
Coleonyx variegatus STEJNEGER AND BARBOUR, 1917, p. 43.

RANGE.—Texas to California and northern Lower California.

LOWER CALIFORNIAN RECORDS.—Santa Rosalia, Mulege, Mocquard, 1899, p. 300; San Felipe, Meek, 1905, p. 4.

Ctenosaura hemilopha Cope

Ctenosaura hemilopha COPE, 1863, p. 105; STEJNEGER AND BARBOUR, 1917, p. 44.
Ctenosaura conspicuosa DICKERSON, 1919, p. 461.[1]
Ctenosaura insulana DICKERSON, 1919, p. 462.[2]

RANGE.—Lower California, north to San Esteban Island, in the Gulf of California.

LOWER CALIFORNIAN RECORDS.—Cape St. Lucas, Cope, 1863, p. 105; La Paz, Yarrow, 1882, p. 71; San José del Cabo, Miraflores, Agua Caliente, Pescadero, Sierra San Lazaro, Van Denburgh, 1895, p. 88; San Pedro, Triunfo, San Antonio, San Bartolo, Buena Vista, Santiago, Todos Santos, Van Denburgh and Slevin, 1921*a*, p. 55.

This species was collected by the Albatross Expedition at Miraflores on the peninsula (A. M. N. H. Nos. 5665–7, U. S. N. M. Nos. 64554–6), on Ceralvo Island (A. M. N. H. No. 5568, U. S. N. M. No.

[1]Type: U. S. N. M. No. 64439.
[2]Type: U. S. N. M. No. 64440.

64553) on San Esteban Island, near Tiburon Island (A. M. N. H. No. 2278, U. S. N. M. Nos. 64439, 64551–2), and Lower California (A. M. N. H. Nos. 5639–41, 5657–8, U. S. N. M. Nos. 64440, 64557–9).

Specimens in the National Museum, collected by the Biological Survey Expedition, are from Santa Anita (U. S. N. M. Nos. 37578–9), Cape San Lucas (37580–81), and San José del Cabo (37582).

Dickerson, 1919, *loc. cit.*, has named two insular species from San Esteban and Ceralvo Islands, on the basis of this material. Upon careful examination of the types and paratypes, I am unable to maintain their validity even as insular races. The difference in proportions between the two new forms (*loc. cit.*, p. 462) appears to be due to the fact that several of the San Esteban specimens are more or less shrunken from too strong alcohol, while the Ceralvo specimens are females, consequently with somewhat stockier bodies. Furthermore, the records now available do not indicate that all of these specimens are actually from the islands to which they are ascribed by Dickerson; the localities assigned above are from the department catalogue.

The tails of the older males are nearly always more or less injured. The regenerated portion is covered with sharply keeled scales, which are, however, scarcely spinose and not arranged in whorls.

The stomach of A. M. N. H. No. 5641 was entirely filled with the flowers of a leguminous plant.

Dipso-saurus dorsalis lucasensis Van Denburgh

Dipso-saurus dorsalis lucasensis Van Denburgh, 1920*b*, p. 33.

Range.—Cape region of Lower California.

Lower Californian Records.—La Paz, Cape St. Lucas, Yarrow, 1882, p. 54; San Luis Gonzales Bay, Townsend, 1890, p. 144; San José del Cabo, Magdalena Island, Comondu to San Quentin, Miraflores, Van Denburgh, 1895, p. 92; San Ignacio Mocquard, 1899, p. 301; San Pedro, Triunfo, San Bartolo, Buena Vista, Santiago, Agua Caliente, Todos Santos, Van Denburgh and Slevin, 1921*a*, p. 56.

Like Van Denburgh, I am unable to find any difference between Cape specimens of this species and those from Arizona, except the difference in the scales between rostral and nasal in which the sixteen specimens collected by the Albatross Expedition agree excellently with those of the California Academy of Sciences. The localities represented in the collection of the Albatross Expedition are San José del Cabo (A. M. N. H. Nos. 5552–4, 5556–7, U. S. M. N. Nos. 64543, 64547–50), Miraflores (A. M. N. H. No. 5663, U. S. N. M. Nos. 64544–6), and Santa Catalina Island (A. M. N. H. No. 5548). The specimen from

Santa Catalina Island is a juvenile one, the smallest in the series, but apparently indistinguishable from the mainland specimens.

Dipso-saurus dorsalis dorsalis (Baird and Girard)

Crotaphytus dorsalis Baird and Girard, 1852*a*, p. 126.
Dipso-saurus dorsalis Stejneger and Barbour, 1917, p. 44.

Range.— Colorado and Mohave Deserts, east to the Colorado River, northern Lower California.

Lower Californian Records.—San Felipe, Meek, 1905, p. 4; San Xavier, Van Denburgh and Slevin, 1921*a*, p. 56.

Specimens in the Biological Survey collection from northern Lower California come from Volcano Lake (U. S. N. M. No. 37631), and San Felipe Bay (37632). I have also referred Meek's specimen from San Felipe to the typical subspecies. The area of intergradation between the two forms remains to be determined.

Crotaphytus collaris baileyi Stejneger

Crotaphytus baileyi Stejneger, 1890, p. 103, Pl. xii, fig. 1.
Crotaphytus collaris baileyi Stejneger and Barbour, 1917, p. 45.

Range.—Northern Mexico, Arizona, the Great Basin; east in southern New Mexico to southwestern Texas; west to eastern California and Lower California.

Lower Californian Records.—San Felipe, San Salado, Meek, 1905, p. 8; (observed at Cañon Esperanza and Trinidad by Heller); Cerro de las Palmas, Mocquard, 1899, p. 303.

Specimens in the Biological Survey collection come from Volcano Lake (U. S. N. M. No. 37625) and San Pablo (37626). The juvenile specimen from San Pablo, in the same general area as the type locality of *Crotaphytus fasciatus* Mocquard (1899, p. 303, Pl. xiii, fig. 1), is of especial interest for comparison with this form. Mocquard's specimen measured 113 mm. in length, of which the body occupied 40 mm. They are consequently of approximately the same age. The coloration of the back, black with six transverse white lines, is almost exactly the same, Mocquard's specimen having an additional white line. This coloration corresponds with that described by Cope (1900, p. 249) as the juvenile coloration of *C. collaris*. Unfortunately I have no juvenile *collaris* of comparable age at hand, but I am convinced that *fasciatus* is merely a juvenile color phase. The characters other than coloration employed by Mocquard to distinguish *C. fasciatus* are either juvenile or inconstant.

Crotaphytus dickersonæ,[1] new species

Diagnostic Characters.—Closely related to *Crotaphytus collaris baileyi* Stejneger, from which it is distinguished by having the hind leg considerably longer than the body, a longer, more distinctly compressed tail, and slightly enlarged scales on the mid-dorsal line of the tail.

Range.—Known only from the type locality, Tiburon Island.

Type.—U. S. N. M. No. 64451, ♀, Tiburon Island; April 12, 1911, C. H. Townsend, collector (Albatross Expedition).

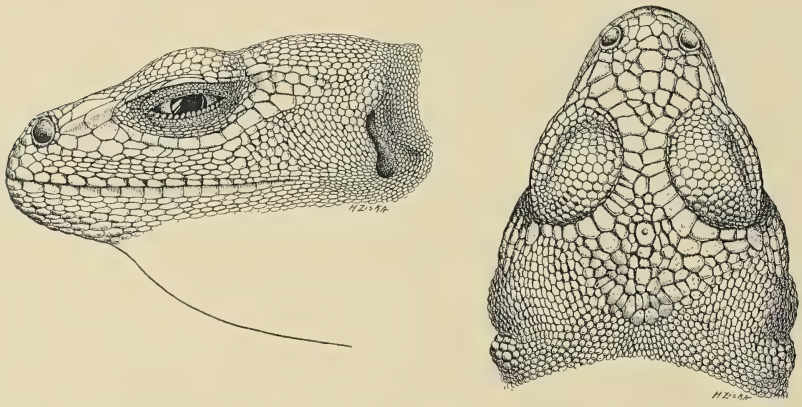

Fig. 2. Lateral and dorsal views of the head of the type of *Crotaphytus dickersonæ*, new species U. S. N. M. No. 64451, ♀. × 1⅓.

Description of Type.—

Habitus of *Crotaphytus collaris*, but legs and tail markedly longer; hind leg reaching considerably beyond the snout when laid along the body; tail more than twice as long as the head and body. Scales of the supraorbital semicircles distinct, as in *C. collaris baileyi;* supraoculars small, occipital slightly enlarged, separated from the supraorbital semicircles by two rows of smaller scales. Auricular opening narrow, oblique, bordered in front by small tubercular scales directed away from the opening. Ventral scales very small, not one-half the size of the ventral caudals. Soles of the feet with a few keeled, tridentate, more or less mucronate scales. Tail compressed with one or two median dorsal scale rows slightly enlarged. Femoral pores 19.

Two black collars, separated by a white band, the posterior wide, complete dorsally, and ending at insertion of the arm, the anterior extending to unite on the midline ventrally. Dorsal surface bluish gray with broad reticulating bands of darker color. More or less regular transverse rows of small white spots. Tail with dark spots proximally. A gular patch and groin patches reddish brown.

Total length, 313 mm.; tail, 218 mm.; snout to posterior border of ear, 30 mm.; width of head, 22 mm.; hind leg, 99 mm.; tibia, 37 mm. The tail forms .70 of the total length.

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[1]Named for Miss Mary C. Dickerson, former Curator of the Department of Herpetology of The American Museum of Natural History.

The single specimen in the collection is a gravid female, considerably injured in collecting. The stomach contents consist of a ground beetle, a large wasp, and the tail of a lizard.

I have compared the type with a series of nineteen *C. collaris baileyi* in The American Museum of Natural History. In these, the average proportion of hind leg to body length is .87, while in the present specimen it is 1.04. The tail length in the series of *C. c. baileyi* averages .66 of the total, .70 in the type of *C. dickersonæ*.

It is possible that this species will be found to extend on the Mexican mainland and that it will ultimately be referred to a subspecific rank under *C. collaris*, occupying the southern portion of the range of the species on the western coast of Mexico.

Crotaphytus insularis Van Denburgh and Slevin

Crotaphytus insularis Van Denburgh and Slevin, 1921*b*, p. 96.

Range.—Angel de la Guardia Island.

Crotaphytus wislizenii Baird and Girard

Crotaphytus wislizenii Baird and Girard, 1852*b*, p. 340, Pl. iii; Stejneger and Barbour, 1917, p. 46.

Crotaphytus copeii Yarrow, 1882*a*, p. 441; Stejneger and Barbour, 1917, p. 45.

Range.—Idaho, the Great Basin, southward into Mexico, southern California and Lower California.

Lower Californian Records.—La Paz, Yarrow, 1882*a*, p. 441; Magdalena Island, Van Denburgh, 1895, p. 93; San Tomas, 1896, p. 1004; San Quentin, Meek, 1905, p. 8; Cedros Island, Van Denburgh and Slevin, 1914, p. 144; Tiburon Island, Dickerson, 1917, p. 96.

Specimens in the Biological Survey collection come from Ensenada (U. S. N. M. No. 37629) and Yubay (37630). The record from Ensenada extends the range of this species northward on the Pacific coast of Lower California, the nearest previous record being Santo Tomas. The record from Yubay, in the central part of the peninsula, fills a gap in the known distribution, connecting the Cedros Island record with those to the north and south.

I have followed Van Denburgh (1905, p. 25) in regarding the Lower Californian *Crotaphytus* of this type as *C. wislizenii*. The specimens secured by the Albatross Expedition in 1911, one each on Cedros and Tiburon Islands, are certainly insufficient to establish the validity of *C. copeii*, much less of insular races, in view of the great variability of typical *wislizenii*. Larger series from the peninsula may reëstablish *C. copeii*, and I append the measurements of the two insular specimens for reference.

Number	A. M. N. H. No. 5544	U. S. N. M. No. 64464
Locality	Cedros Island	Tiburon Island
Sex	♂	♂
Length	358 mm.	377 mm.
Tail	239 mm.	266 mm.
Length of Head	32 mm.	30 mm.
Breadth of Head	23 mm.	21 mm.
Hind Leg	88 mm.	93 mm.
Tibia	33 mm.	34 mm.

Key to Distinguish the Species of *Crotaphytus* in Lower California

Interorbital scales in two rows; a series of subequal suboculars. . *C. collaris baileyi.*

Interorbital scales in three or four series, a single much enlarged subocular. *C. wislizenii.*

Sauromalus ater Duméril

Plate L, Figure 3

Sauromalus ater Duméril, 1856, p. 536, Pl. xxiii, fig. 3.

Sauromalus sp. Stejneger, 1891*b*, p. 411.

Sauromalus interbrachialis Dickerson, 1919, p. 463 [1]

Range.—Lower California, north to the island Espiritu Santo, off La Paz.

Lower Californian Records.—Island of Espiritu Santo, Stejneger, 1891, p. 411.

Two specimens of *Sauromalus* from La Paz are included in the collections of the Albatross Expedition. These are possibly from the island of Espiritu Santo, off La Paz, like the specimen recorded by Yarrow and Stejneger.

In defining *Sauromalus hispidus* in 1891, Stejneger remarked the discrepancy between the *Sauromalus ater* of California and Arizona and the single immature specimen from Lower California. With two additional specimens from the same locality, I believe the recognition of a distinct species is fully warranted. Mr. Charles L. Camp has pointed out to me the fact that it is highly improbable that the type of *S. ater* Duméril, collected by Lieut. Jaurès during the circumnavigating voyage of the frigate Danaide, and presented without locality to the Museum d'Histoire Naturelle in Paris, could have been collected in California or Arizona, since *Sauromalus* does not reach the coast of California. With this in mind, I applied to Professor Louis Roule, of the Museum d'Histoire Naturelle in Paris, for information regarding the type of *ater*, and he has very kindly supplied me with an excellent photograph of the ventral aspect of the type. The ventral scales from anus to gular fold number about 135, compared with a range of 160–182 in the California

[1] Type: U. S. N. M. No. 64443.

and Arizona specimens described by Stejneger. In the two specimens from La Paz in the Albatross collection (U. S. N. M. No. 64443, A. M. N. H. No. 6808), the ventral scales number 126 and 133, and in the specimen from Espiritu Santo already mentioned (U. S. N. M. No. 12633) they number 139.

In view of this agreement in the ventral scale character, I believe we are justified in assigning the name *ater* definitely to the species in southern Lower California.

	U. S. N. M.	A. M. N. H.	U. S. N. M.
Number	64443	6808	12633
Locality	La Paz	La Paz	Espiritu Santo Id.
Total Length	250 mm.	153 mm.	280 mm.
Tail Length	130 mm.	85 mm.	165 mm.
Femoral Pores	14–14	14–14	15–15
Dorsal Scales in Head Length	32	28	26
Ventral Scales from Gular Fold to Anus	133	126	139
Scales about Thickest Part of Tail	60	40	. .

Sauromalus obesus (Baird)

Euphryne obesa Baird, 1858, p. 253.
Sauromalus ater Stejneger and Barbour, 1917, p. 46.

Range.—Southern Nevada, southwestern Utah, Arizona, southern California, and northern Lower California, south to Mulege on the Gulf side.

Lower Californian Records.—Santa Agueda, San Ignacio, Mulege, Mocquard, 1899, p. 302; "Northern Lower California," Meek, 1905, p. 9.

The application of the name *ater* to the Lower Californian species releases Baird's name *obesus*, type locality Fort Yuma, Arizona, for the form occurring in the United States. Dr. Roule has kindly included a photograph of the ventral surface of one of the specimens recorded by Mocquard from the middle of the gulf side of the peninsula of Lower California with the photograph of the type of *ater*. The ventral scale count, 160, agrees closely with that of the series described by Stejneger (*loc. cit.*).

Sauromalus varius Dickerson

Plate XLIX

Sauromalus varius Dickerson, 1919, p. 464.[1]

Range.—Known only from the type locality, San Esteban Island, to which it is doubtless confined.

[1]Type: U. S. N. M. No. 64441. Paratypes: U. S. N. M. Nos. 64560–71, A. M. N. H. Nos. 2701 5610–20, 5625–32, 5634–5, 5637–8.

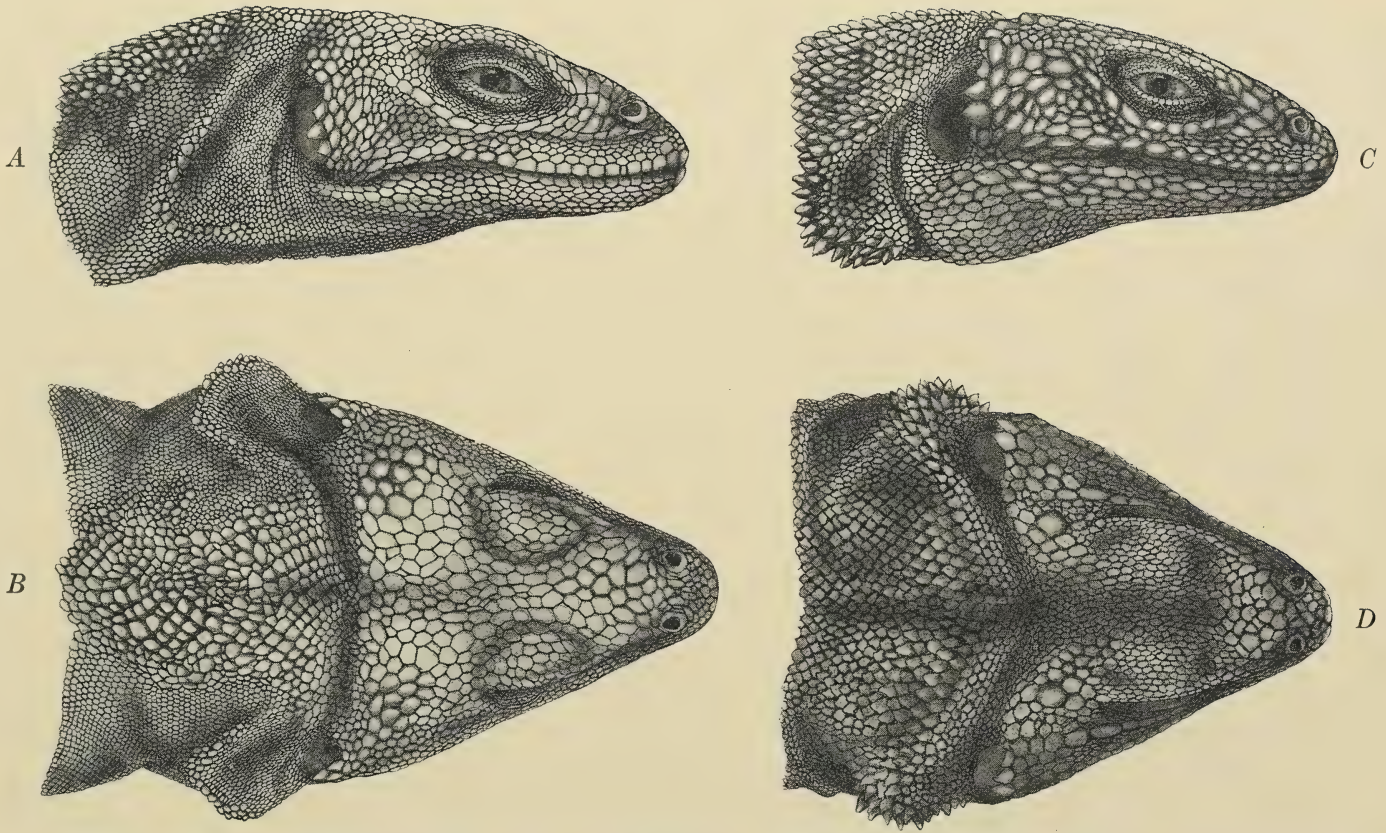

Fig. 3. *A* and *B*, lateral and dorsal views of the head and neck of *Sauromalus varius* Dickerson, A. M. N. H. No. 5630. × 1⅓. *C* and *D*, lateral and dorsal views of the type of *Sauromalus townsendi* Dickerson, U. S. N. M. No. 64442. × 1⅓.

The Albatross Expedition in 1911 secured forty-one specimens of this large lizard from San Esteban. Comparison with *S. hispidus* from Angel de la Guardia, *S. ater* from the peninsula, and *S. obesus* from California proves that it is quite as distinct a species as *S. hispidus*. From *S. obesus* it is distinguished by the distinctly smaller auricular spines and the smaller number of ventral scales, from *S. ater* by the large size and coloration, while from *S. townsendi* and *S. hispidus*, it is readily distinguished by the non-spinose nuchals.

In coloration the species is strikingly distinct from the much darker adults of *obesus* and *hispidus*. I have no large specimens of *S. ater* and *S. townsendi* but neither of these species shows any trace of the blotching of *S. varius*. The dorsal dark patches take on most irregular shapes and arrangements, never symmetrical, sometimes ill-defined, sometimes rather sharply set off from the ground color. Ventrally, the color is yellowish with a few small dark spots. Even on the tail the arrangement of the dark color is not symmetrical, as in juvenile *hispidus*.

The Albatross Expedition visited San Esteban Island on April 13, 1911. Large numbers of the big spotted lizards of this species, as well as of *Ctenosaura hemilopha*, were conspicuous, and were secured by pulling them out from under the rocks where they took refuge, or by turning over the rocks.

Dr. J. N. Rose, who was a member of the party, has kindly identified the stomach contents of three specimens. He writes: "The contents of two stomachs are entirely made up of the flowers of *Pachycereus pringlei* Britton and Rose. The third stomach is also largely filled with this cactus flower, but also contains numerous small leaflets of some leguminous plants, probably some *Cercidium*."

Measurements and scale characters of fifteen specimens of this species may be tabulated as follows.

	Extremes	Average
Total Length	465–615 mm.	513 mm.
Tail-Length	245–335 mm.	280 mm.
Tail-Length/Total Length	.53–.60	.55
Femoral Pores	15–19	
Dorsal Scales in Head Length	35–41	37
Ventral Scales from Gular Fold to Anus	136–151	142
Scales Around Thickest Part of Tail	69–76	72

Sauromalus townsendi Dickerson

Sauromalus townsendi Dickerson, 1919, p. 464.[1]

Range.—Tiburon Island; coast of Sonora?

[1]Type: U. S. N. M. No. 64442.

This species is founded on a unique specimen collected by the Albatross Expedition on Tiburon Island, April 11–13, 1911. It is in several respects intermediate between *S. obesus* and *S. hispidus*, but fully distinct from both. The nuchals and scales of the gular pouches are much larger and more spinose than in *S. obesus* of the same size, but much less spinose than in *S. hispidus*, while the dorsal scales are not appreciably spinose. The number of ventral scales from gular fold to anus is 125, which allies it to *hispidus* and distinguishes it from *obesus*. The number of scales around the thickest part of the tail is 60, not 90 as in the original description. It is interesting that the species on Tiburon Island should be sharply distinguished from that on San Esteban, only a few miles away. Belding (1893, p. 97) records seeing *Sauromalus* at Guaymas, on the Mexican mainland, not far south of Tiburon and it is not unlikely that this will be found to be *Sauromalus townsendi*.

Dr. J. N. Rose has kindly identified the stomach contents of this specimen as made up chiefly of *Fouquieria splendens* Engelmann and leaflets of the desert shrub *Olneya tesota* Gray.

Sauromalus hispidus Stejneger

Plate L, Figures 1 and 2

Sauromalus hispidus Stejneger, 1891*b*, p. 409; Stejneger and Barbour, 1917, p 46.

Range.—Angel de la Guardia Island, Gulf of California.

Fourteen specimens of this species were secured by the Albatross Expedition (A. M. N. H. Nos. 2696–97, 5566–67, 5607–09, 5705, and U. S. N. M. Nos. 64572–77).

This species equals the San Esteban *Sauromalus varius* in size, the maximum in the series collected by the Albatross Expedition of 1911 being 608 mm., (615 in *S. varius*). The adults in alcohol are very dark in color, differing strikingly in this respect from the *S. varius*. It is difficult to see how even a large capacity for color change in life could lessen the distinction in this respect between the two species.

Juvenile specimens (150 mm.) are light gray in color, with four dark crossbands on the back and six on the tail, those on the tail being most sharply defined. In this coloration, the young *hispidus* agree with juvenile *S. obesus*.

Measurements and scale characters of specimens of *S. hispidus* in The American Museum of Natural History:

	Number of Specimens	Extremes	Average
Total Length	9	435–608 mm.	526 mm.
Tail Length	9	230–318 mm.	280 mm.
Tail Length/Total Length	13	.50–.54	.52
Femoral Pores	13	12–16	
Dorsal Scales in Head Length	13	15–23	18
Ventral Scales from Gular Fold to Anus	13	113–122	117
Scales Around Thickest Part of Tail	12	39–50	45

Key to the Species of the Genus *Sauromalus*

1. Nuchals distinctly spinose....2.
   Nuchals not distinctly spinose....3.
2. Largest nuchals about equal to auricular spines; dorsal scales in head length, 16. *S. hispidus.*
   Largest nuchals about one-half the length of auricular spines; dorsal scales in head length, 28....*S. townsendi.*
3. Ventral scales from gular fold to anus more than 155....*S. obesus.*
   Ventral scales from gular fold to anus less than 155....4.
4. Dorsal scales in head length 26–32; adult size under 400 mm....*S. ater.*
   Dorsal scales in head length 35–41; adult size over 500 mm....*S. varius*

Callisaurus crinitus Cope

Plate LI, Figure 1; Plate LII, Figures 1 and 3

Callisaurus crinitus Cope, 1896*a*, p. 1049; Stejneger and Barbour, 1917, p. 47.

Range.—Balenas Bay and San Bartolome Bay, Pacific Coast of Lower California, to the Magdalena Plain.

Lower Californian Records.—Balenas Bay, Cope, 1889, p. 147.

This exceptionally interesting species was taken by the Albatross Expedition at Abreojos Point (A. M. N. H. No. 5390), not far from the type locality, and at San Bartolome Bay, some distance to the north (A. M. N. H. Nos. 5369–71, 5501–2, 5504, U. S. N. M. No. 64530).

In the series at hand, one male (U. S. N. M. No. 64530) has three lateroventral bars on both sides, followed by a large and distinct spot on one side, which is less distinct on the other side; two males (A. M. N. H. Nos. 5371, 5502) have three bars on each side, the posterior ones being prolonged caudad from its ventral angles; in A. M. N. H. No. 5501, there are three bars followed by a spot on one side, while on the other side the middle bar forks slightly below the lateral fold, so that there appears to be four bars followed by a spot; in A. M. N. H. No. 5369, the middle bar forks in the other direction, i.e., it is single ventrally and divides on the side. The latter condition appears in A. M. N. H. Nos. 5502 and 5371, but the division is concealed by the lateral fold.

Two specimens, one of each sex, in the Biological Survey collection from Santo Domingo (U. S. N. M. Nos. 37644, 37646) greatly extend the range of this species which has hitherto been known only from the type locality, Ballenas Bay, and San Bartolome Bay (Albatross collection). The occurrence of a species characteristic of the Vizcaino Desert district on the Magdalena Plain adds to the evidence that the latter is faunally more closely allied to the Vizcaino area than to the Cape district proper, as I have elsewhere indicated.

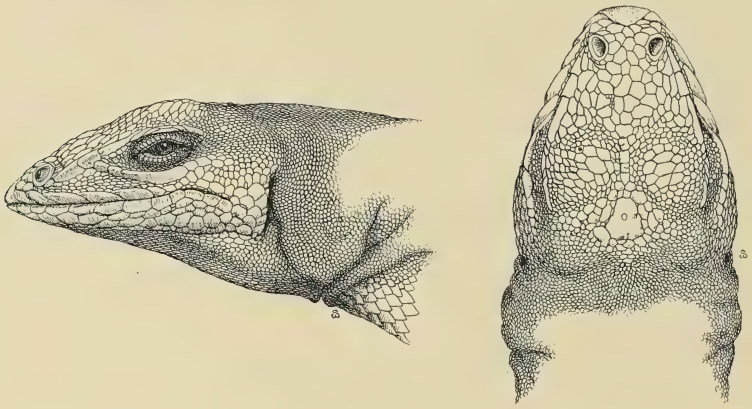

Fig. 4. Lateral and dorsal views of the head of *Callisaurus crinitus* Cope, U. S. N. M. No. 64530. × 2.

In the male specimen from Santo Domingo the fringes of the toes appear to be less strongly developed than in specimens from San Bartolome Bay, but the specimen shows signs of having been subjected to friction, and the points of some of the fringe scales are broken off. There are four lateroventral bands on one side, three on the other. The female specimen has the fringe scales well developed.

Callisaurus draconoides Blainville

Plate LI, Figures 1 to 3

Callisaurus draconoides Blainville, 1835, p. 286, Pl. xxiv, fig. 2; Stejneger and Barbour, 1917, p. 47.

Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, Baird, 1859*a*, p. 299; La Paz, Yarrow, 1882, p. 50; San José del Cabo, Sierra San Lazarro, Van Denburgh, 1895, p. 95; San Ignacio, Santa Rosalia, Mocquard, 1899, p. 305; Todos Santos, Miraflores, Agua Caliente, Buena Vista, San Bartolo, San Antonio, Triunfo, San Pedro, Van Denburgh and Slevin, 1921*a*, p. 57.

Thirteen specimens of this species were collected by the Albatross Expedition in 1911, from the following localities: Cape San Lucas (U. S. N. M. Nos. 64514–8); San José del Cabo (A. M. N. H. Nos. 5392–95); and Miraflores (A. M. N. H. Nos. 5391, 5659–60, U. S. N. M. No. 64519).

Specimens in the Biological Survey collection come from Cape San Lucas (U. S. N. M. No. 37637), Espiritu Santo Island (37638), and La Paz (37634).

The specimens from San Ignacio and Santa Rosalia recorded by Mocquard (*loc. cit.*) are north of the established range of this species, but the fact that he mentions three ventral spots makes it fairly certain that he had true *draconoides* before him.

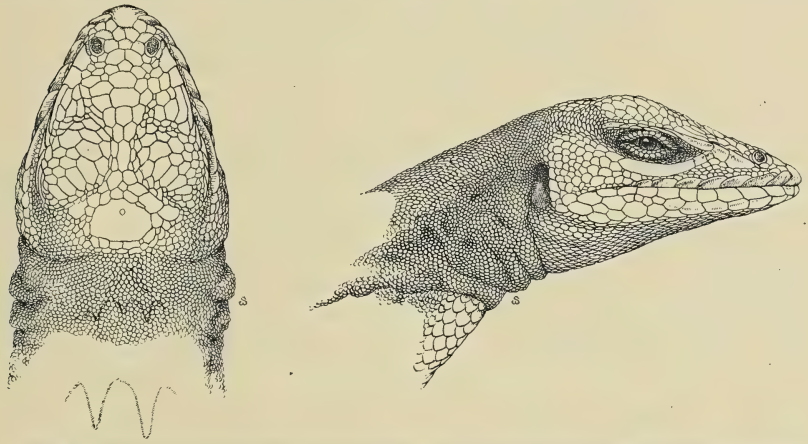

Fig. 5. Lateral and dorsal views of the head of *Callisaurus draconoides* Blainville, U. S. N. M. No. 64514. × 2.4.

The presence of a black spot posterior to the two lateroventral black bars is a conspicuous difference between *C. draconoides* and the other species of the genus, and is invariable in the series before me; the dorsal bars are often confluent, forming continuous wavy transverse markings.

Callisaurus splendidus Dickerson

Plate LI, Figure 1

Callisaurus dracontoides (part) Townsend, 1890, p. 144.
Callisaurus splendidus Dickerson, 1919, p. 467.

Range.—Angel de la Guardia, Gulf of California.

The Albatross Expedition of 1911 collected eight specimens of a *Callisaurus* on Angel de la Guardia Island (A. M. N. H. Nos. 5338, 5342, 5373–75, 5396, 6807, U. S. N. M. No. 64254 (Type)).

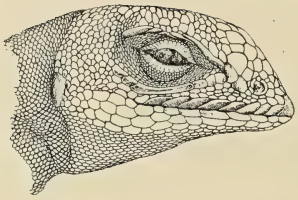

Fig. 6. Lateral view of the head of *Callisaurus splendidus* Dickerson, A. M. N. H. No. 5373. × 2.

The distinctness of this species rests primarily on the convex frontal region of the head, which is accompanied by an enlargement of the scales in the same area, and the low number of femoral pores. The tail is rather short, ranging from .54 to .56 of the total, mean .55. The length of the hind leg is moderate, ranging from .86 to .98 of the length from snout to vent, mean .92. The occipital is in contact with the supraorbital semicircles in seven out of eight specimens.

Callisaurus ventralis inusitatus (Dickerson)

Plate LI, Figure 1; Plate LII, Figure 2

Callisaurus inusitatus Dickerson, 1919, p. 465.[1]

Callisaurus ventralis ventralis (part) Stejneger and Barbour, 1917, p. 47.

Range.—Tiburon Island and adjacent part of Sonora, Mexico.

Twenty-nine specimens of a species of *Callisaurus* were collected on Tiburon Island by the Albatross Expedition.

In spite of the fact that I have no actual intergrades between this form and the Arizonan *C. ventralis*, the nature of the characters used to distinguish it from *ventralis ventralis* on one hand and *ventralis gabbii* on the other is such that I prefer to give it subspecific rank.

The series before me is rather strikingly different from *C. ventralis ventralis* in habitus, being much more slender bodied and longer limbed. This character does not appear in its real value in a tabulation of measurements, *C. ventralis ventralis* with the same length of body and tail being much heavier. The length of the hind leg is variable but averages much longer than in the Arizonan specimens, while the femoral pores, averaging 18, distinguish it from the form in southern California and Lower California (*C. ventralis gabbii*).

The character of the union of the black lateroventral bands inferiorly in the males is invariable in the present series.

Callisaurus ventralis gabbii Cope

Plate LI, Figure 1

Callisaurus ventralis gabbii Cope, 1900, p. 272.

Callisaurus plasticus Dickerson, 1919, p. 466.[2]

Callisaurus carmenensis Dickerson, 1919, p. 465.[3]

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[1]Type: U. S. N. M. No. 64256. Paratypes: U. S. N. M. Nos. 64520–29, A. M. N. H. Nos. 5317–19, 5322, 5325–37, 5346.

[2]Type: U. S. N. M. No. 64255. Paratypes: U. S. N. M. Nos. 64531–42; A. M. N. H. Nos. 5308–14, 5346–48, 5350–54, 5357–60, 5381–87.

[3]Type: U. S. N. M. No. 64253.

Callisaurus ventralis ventralis (part) Stejneger and Barbour, 1917, p. 47.

Range.—Lower California from La Paz north to the deserts of southern California and adjacent areas in Arizona.

Lower Californian Records.—San Luis Gonzales Bay, Townsend, 1890, p. 144; El Llano de Santano, San Ignacio, Santa Margarita Island, Van Denburgh, 1895, p. 97; San Fernando, Seven Wells (Salton River), Gardner's Laguna (Colorado Desert), Cope, 1900, p. 273; Trinidad, San Matias, San Felipe, Cañon Esperanza, San Antonio, Matomi, and Aguas Escondita, Meek, 1905, p. 7; San José Island, Carmen Island, Agua Verde Bay, Conception Bay, Mulege, San Francisquito Bay, Dickerson, 1919, pp. 465–66; San Xavier, Van Denburgh and Slevin, 1921*a*, p. 57.

Specimens in the Biological Survey collection come from Alamo (U. S. N. M. No. 37642), Rancho San Antonio (37640–1), Volcano Lake (37647–9), Cocopah Mts., east base (37650–1), San Felipe Bay (37635–6), San Francisquito (37639), San Ignacio (37643), and Santo Domingo, Magdalena Plain (37645).

With the northern Lower Californian specimens collected by Heller and recorded by Meek (*loc. cit.*) before me in addition to those of the Biological Survey collection, I am unable to find any adequate character by which they could be distinguished from the peninsular specimens described by Dickerson as *C. plasticus*. An examination of the measurements of all the Lower Californian specimens at hand indicates that they are not distinguishable; the results of the tabulation may be condensed as follows.

Locality	No. of Spec.	Tail / Total Length		Hind Leg / Body		Femoral Pores	Occipital and Supraorbital Semicircles	
		Extremes	Mean	Extremes	Mean	Mean	In Contact	Separate
Northern Lower California (Heller Coll.)	18	.56–.60	.58	.85–1.00	.94	15.1	1	17
Middle Lower California San Francisquito Bay to Conception Bay	25	.58–.63	.59	.85– .97	.92	14.8	9	16
Southern Lower California, Carmen Id. to San José Id.	23	.57–.65	.60	.86–1.01	.94	15.1	2	12

If the above conclusions are correct, i.e., that a single subspecies of *C. ventralis* extends from Yuma, Arizona, to La Paz, Lower California, it seems preferable to introduce the name *gabbii* in spite of the very inadequate description of Cope in 1900. Cope had specimens from northern Lower California (the type locality) before him, at least the National Museum specimens above mentioned and probably also the original specimens collected by Gabb on which his manuscript name in 1875 was based.

I do not find any characters in the type and paratype of *C. carmenensis* which warrant its distinction from *C. gabbii*.

In seventy-eight specimens from Tucson, I find a mean tail-length of .54 of the total, and the length of the hind leg .86 of that of the body, the average of femoral pores higher (17.4) and the proportion of specimens with the occipital separated from the supraorbital semicircles a minority, instead of a majority, as in the Lower Californian series.

Turning to the description of *C. ventralis myurus* (Richardson, 1915, p. 408), I find that he has compared the proportionate tail-length in *myurus* from Pyramid Lake, Nevada, with the tail-length of a series of *ventralis* from Yuma, Arizona, and San Diego County, California, with an average of .55 for the former and .58 for the latter. (I have transposed his figures for body/tail to tail/body and tail, for comparison with mine.) It will be seen that the Yuma specimens agree with the Lower Californian ones, while *myurus* has a tail of practically the same length as Tucson *ventralis*, from which it is distinguished, therefore, chiefly by the lower number of femoral pores. As the type locality of *ventralis* is "New Mexico west of the Rio Grande" (including Arizona in 1852), I believe I am justified in regarding the Tucson specimens as typical *ventralis*, distinct from the form at Yuma.

Additional evidence on this question is furnished by the character of the occipital, which may be more or less broadly in contact with the supraorbitals or separated from them by a row of scales. In our series of *C. v. gabbii* as above defined, twelve specimens have the supraorbitals in contact with the occipital and forty-three have an intercalated row of scales. In the seventy specimens examined from Tucson, the proportions are reversed, fifty-one specimens having the supraorbitals and occipital in contact, while nineteen have them separated. Dr. Stejneger has kindly examined a series of specimens in the National Museum from west of the mouth of the Colorado River in this respect, and states that out of fifty-seven specimens, seventeen have the supraorbitals and the occipital in contact, six have them in contact on one side, separated on the other,

and thirty-four have them separated by a row of scales. The general conclusion, therefore, is that the range of *C. v. gabbii* should include the desert areas of southern California and of Arizona west of Tucson.

In the larger series of specimens reported by Van Denburgh (1921, p. 33) the notable difference in tail-length between the series from Yuma and the other Arizonan specimens confirms this conclusion. In his table, however, the specimens from Cavecreek, Maricopa County, are indistinguishable from *myurus*. It is evident, therefore, that further study is required to establish the limits of *ventralis* and *myurus*. The range of variation in the characters above discussed is shown in the following tabulation for the several forms of *Callisaurus*.

	Tail / Total Length			Hind Leg / Body Length			Femoral Pores		Occipital and Supraorbital Semicircles	
	No. Spec.	Extremes	Mean	No. Spec.	Extremes	Mean	No. Spec.	Mean	In Contact	Separated
Callisaurus										
ventralis gabbii	116	.55–.65	.59	64	.85–1.01	.93	116	15.5	27	77
ventralis ventralis	70	.51–.56	.54	70	.78– .95	.86	78	17.4	51	19
ventralis myurus	53	.54–.58	.55				53	14.2		
ventralis inusitatus	15	.56–.59	.57	29	.88–1.04	.96	29	18.0	16	13
splendidus	8	.54–.56	.55	8	.86– .98	.92	8	12.2	7	1
draconoides	16	.49–.59	.54	16	.82– .97	.89	16	15.1	13	3
crinitus	9	.55–.58	.56	9	.83– .93	.86	9	19.0	2	4

Uma notata Baird

Plate LIII

Uma notata Baird, 1858, p. 253.

Callisaurus notatus Stejneger and Barbour, 1917, p. 47.

Range.—Deserts of southern California and northeastern Lower California.

Lower Californian Records.—Gardner's Laguna, Cope, 1900, p. 281; Laguna Salada, 80 mi. south of Mexicali, Van Denburgh and Slevin, 1921*a*, p. 56.

While *Uma* (of which I recognize only a single species) is unquestionably more closely allied to *Callisaurus* than to any other iguanid genus, I do not believe that it is directly allied to *Callisaurus crinitus*, nor that the occurrence of digital fringes in *crinitus* necessitates the reference of *Uma notata* to *Callisaurus*.

Uma is distinguished from all of the species of *Callisaurus* by its unique dorsal color pattern and structurally by the presence of an inter-

calated row of small subdigital scales between the fringe and the subdigital lamellæ proper. The accompanying figures illustrate these characters of the digits in *Uma notata, Callisaurus crinitus* and *Callisaurus ventralis*. It seems evident that *crinitus* is much more closely allied to *ventralis* than to *Uma notata,* and that the development of the fringe has been independent in the two forms.

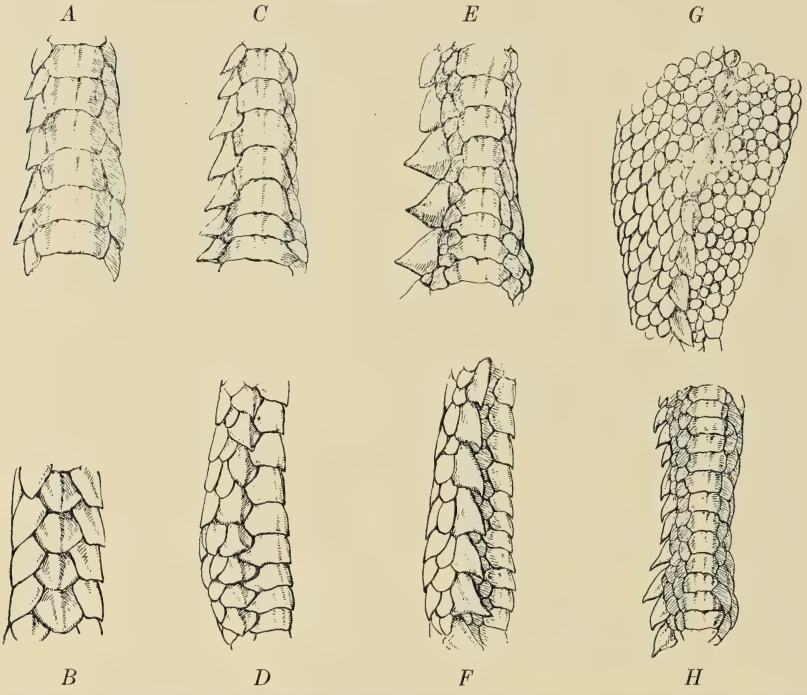

Fig. 7. *A* and *B*, ventral and posterior lateral views of the base of the fourth toe of *Callisaurus ventralis ventralis* (A. M. N. H. No. 2454). *C* and *D*, same of *Callisaurus crinitus* (U. S. N. M. No. 64530) *E* and *F*, same of *Uma notata*, Field Mus. No. 1203. *G*, posterior lateral surface of foot between base of fourth and fifth toes, showing extension of the fringe scales and transition to smooth scales of same specimen. *H*, distal joint of third toe, showing narrowness of the ventral lamellæ and insertion of a double row of small scales between them and the fringe scales, same specimen. All × 6.6.

Key to the Species of *Callisaurus* and *Uma*

1. Digits with or without a lateral fringe; subdigital scales broad, in a single row; coloration not ocellated..... .....*Callisaurus.*—2.
   Digits with a long lateral fringe; subdigital scales in more than one row; dorsal coloration ocellated. (A single species, *Uma notata;* deserts of southern California and adjacent parts of Arizona.).....*Uma.*

2. Digits with a lateral fringe of long spinose scales. (Pacific Coast of Lower California.) ..... *C. crinitus.*
   Digits not fringed ..... 3.
3. Lateroventral black spots, 3; dorsal spots more or less united into a scalloped crossband. (Confined to Cape District of Lower California.) *C. draconoides.*
   Lateroventral spots, 2; dorsal spots more widely separated ..... 4.
4. Frontal region of head strongly convex; femoral pores usually 12. (Angel de la Guardia Island, Gulf of California.) ..... *C. splendidus.*
   Frontal region of head plane or nearly so; femoral pores more than 12 (average). *C. ventralis.*—5.
5. Lateroventral black spots confluent at their lower extremities; body very slender; femoral pores (average) 18; hind leg averaging .96 of body length; tail .57 of total. (Tiburon Island and Sonora, Mexico.) *C. ventralis inusitatus.*
   Lateroventral bars always distinct ..... 6.
6. Femoral pores (average) 14; tail length (average) .55. (Pyramid Lake, Nevada) ..... *C. ventralis myurus.*
   Femoral pores (average) more than 14 ..... 7.
7. Femoral pores (average) 17 or more; tail length averages .54; hind leg averages .86. (Central Arizona; border of the Plateau.) ..... *C. ventralis ventralis.*
   Femoral pores average less than 17; tail length averages .58 or more; hind leg averages .92 or more. (Lower California from La Paz north; the Colorado Desert.) ..... *C. ventralis gabbii.*

Uta thalassina Cope

Uta thalassina Cope, 1863, p. 104; Stejneger and Barbour, 1917, p. 52.
Uta repens Van Denburgh, 1895, p. 102; Pl. vii–viii, figs. *a–e.*

Range.—Southern Lower California.

Lower Californian Records.—Cape St Lucas, Cope, 1863, p. 104; La Paz, Yarrow, 1882, p 54; Playitas, San Lazaro, Belding, 1887, p. 96; San José del Cabo, San Bartolome, Corral de Piedras (Sierra El Taste), Miraflores, Sierra San Lazaro, Comondu, Van Denburgh, 1895, p. 99; Mulege, Mocquard, 1899, p. 311. San Xavier, Triunfo, San Bartolo, Agua Caliente, Sierra Laguna, Van Denburgh and Slevin, 1921*a*, p. 57.

The Albatross Expedition collected six specimens of this species at San Bernardo Mountain, Lower California (A. M. N. H. Nos. 5547, 5650–51, 5653–54, U. S. N. M. No. 64485).

Uta repens Van Denburgh was based on a single specimen, distinguished from *Uta thalassina* by (1) shorter hind leg, (2) shorter head, and (3) four dorsal black bars instead of three, followed by three dusky bars. In the typical coloration of *Uta thalassina*, there are three distinct anterior black bars on the back, followed by two dusky ones. The anterior bars are outlined with very light greenish gray, leaving a darker interspace between the true bars, which may approach them in depth of pigmentation: the two posterior bars are less distinctly outlined, but in

one specimen I am able to trace the pattern of five primary crossbars (three black and two dusky), with four secondary bars on the interspaces. In other specimens, only the anterior secondary bars are evident, making seven crossbands, as in the type of *U. repens*. The length of the hind leg, when compared with that of the body from snout to anus, varies from .58 to .73 (ten specimens). In the type of *repens*, the ratio is .60, and in one of the specimens of *thalassina*, whose measurements are given by Van Denburgh, it is likewise .60. The length of the head in *repens* is .31 of that of the body, .23–.27 in the available *thalassinas*. In view of these facts, I do not think that *U. repens* can be maintained.

Uta mearnsi Stejneger

Uta mearnsi Stejneger, 1894*a*, p. 589; Stejneger and Barbour, 1917, p. 50.

Range.—Boundary region of Lower California and California.

Lower Californian Records.—"Seventy-five miles south-east of San Diego," Lockington, 1880, p. 295 (=Ensenada, Todos Santos Bay, *vide* Stejneger, 1894*a*, p. 591); Santa Rosalia, Mocquard, 1899, p. 308; San Salado, San Matias, Cañon Esperanza, Parral, Matomi, Meek 1905, p. 9.

Specimens in the Biological Survey collection come from La Providencia Cañon, east base of San Pedro Martir Mts., (U. S. N. M. Nos. 37627–8).

The specimen (Acad. Nat. Sci. Phila., No. 12644, Cope collection) recorded by Lockington as *U. thalassina* is a typical *Uta mearnsi*. It is interesting that a specimen of so distinct a species should have passed through Cope's hands and remained undescribed.

In two specimens of this species with a reproduced tail (in the collection of the Field Museum) the tail is as long as, or slightly longer than, the normal tail.

Uta stansburiana stejnegeri Schmidt

Uta stansburiana elegans (part) Stejneger and Barbour, 1917, p. 52.

Uta stansburiana stejnegeri Schmidt, 1921, p. 1.

Range.—Western Texas and northern Mexico through New Mexico and Arizona to the coast range in California; northeastern Lower California; Angel de la Guardia Island, Gulf of California.

Lower Californian Records.—San Matias, Cañon Esperanza, Agua de las Fresas, San Felipe, Parral, and Matomi, Meek, 1905, p. 10.

A specimen in the National Museum (U. S. N. M. No. 37689), from Volcano Lake, northeastern Lower California, is a typical *stejnegeri*. A single immature specimen in the Albatross collection (U. S N. M. No. 64487), from Angel de la Guardia Island, where a distinct form might be expected, resembles *stejnegeri* in scales and leg length. It is probable

that some of the specimens recorded by Meek, and here assigned to this species on geographical grounds, may be intergrades between *stejnegeri* and *hesperis*. Two specimens in the Academy of Natural Sciences of Philadelphia, collected by S. N. Rhoads in the Cocopah Mountains, northeastern Lower California, represent this form (A. N. S. P. Nos. 16102, 16106).

Uta stansburiana hesperis Richardson

Uta stansburiana hesperis Richardson, 1915, p. 415. Stejneger and Barbour, 1917, p. 52.

Uta parva Dickerson, 1919, p. 471.[1]

Range.—Coastal region of southern California and Lower California, south to San Bartolome Bay.

Lower Californian Records.—San Bartolome Bay, Townsend, 1890, p. 144; Todos Santos Bay, Lockington, 1880, p. 295; Guadalupe to Colnett, San Tomas to Guadalupe, Van Denburgh, 1895, p. 105; San Rafael, San Telmo, foothills of San Martir Mt., Van Denburgh, 1896, p. 1004; El Alamo, Hanson's Lagoon, San Salado Cañon, Trinidad, San Antonio, Santa Rosa, and San Quentin, Meek, 1905, p. 10; Ensenada, Van Denburgh and Slevin, 1921*a*, p. 59.

The Albatross collection contains six specimens from San Bartolome Bay on which *Uta parva* is based. I am unable to find any characters sufficient to distinguish this series from *hesperis*. The length of hind leg, given in the original description as 42 mm. (for the type), is in error for 32. A. M. N. H. No. 5431 measures 48 mm. from snout to anus, which is not appreciably different from the average size of *hesperis*. The keeling of the posterior femorals distinguishes it slightly from *concinna*.

Uta martinensis Van Denburgh

Uta martinensis Van Denburgh, 1905, p. 18, Pl. vi; Stejneger and Barbour, 1917, p. 50.

Range.—San Martin Island, off the Pacific coast of Lower California.

The only characters which distinguish this species from *Uta stansburiana hesperis* are the considerably larger size and the slightly larger scales. The type of *martinensis* measured 62 mm. from snout to anus, while the maximum body length recorded for *hesperis* by Richardson is 53 mm.

Uta concinna Dickerson

Uta concinna Dickerson, 1919, p. 470.[2]

Range.—Cedros Island and Natividad Island, off Pacific coast of Lower California.

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[1]Type: U. S. N. M. No. 64258.

[2]Type: U. S. N. M. No. 64257. Paratypes: U. S. N. M. Nos. 64489–93; A. M. N. H. Nos. 5399–407, 5410

Uta concinna was based on sixteen specimens collected on Cedros Island by the Albatross Expedition. Three specimens from Natividad Island, between Cedros and the mainland, in the U. S. National Museum, have also been examined.

The dorsal scales from a point opposite the posterior surface of the thigh to the occipital average 92 in eight male specimens, ranging from 85 to 97. The difference from *Uta stansburiana hesperis* is slight, though the dorsal scales are slightly larger and slightly smoother and the posterior femorals are more weakly keeled in *concinna*. The two latter characters distinguish it also from *stejnegeri*.

Uta palmeri Stejneger

Uta palmeri Stejneger, 1890, p. 106; Stejneger and Barbour, 1917, p. 51.
Range.—San Pedro Martir Island, Gulf of California.

Uta stellata Van Denburgh

Uta stellata Van Denburgh, 1905, p. 21, Pl. viii; Stejneger and Barbour, 1917, p. 52.
Range.—San Benito Islands, off the Pacific coast of Lower California.

The Albatross Expedition collected seven specimens (A. M. N. H. Nos. 5414–5418, 5420, U. S. N. M. No. 64486) on East and West San Benito. These agree excellently with the original description of Van Denburgh. The dorsal scales from the occipital to rump number from 110 to 125 in the specimens examined. The femoral pores in the large series recorded by Van Denburgh and Slevin (*loc. cit.*) average 15.

Uta squamata Dickerson

Uta squamata Dickerson, 1919, p. 471.[1]
Range.—Santa Catalina Island, Gulf of California.

The series of six specimens collected by the Albatross Expedition, on which this species is based, is excellently preserved. The species is a very distinct one, though directly allied to *Uta elegans* of the peninsula. The dorsal scales from the occipital to the base of the tail range from 70 to 78. The length of the hind leg divided by that of the body averages .79, in which respect *squamata* is the only species of the *stansburiana* group approaching *elegans*.

Uta elegans Yarrow

Uta elegans Yarrow, 1882*a*, p. 442.
Uta stansburiana elegans (part) Stejneger and Barbour, 1917, p. 52.
Uta mannophorus Dickerson, 1919, p. 470.[2]

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[1]Type: U. S. N. M. No. 64259.
[2]Type: U. S. N. M. No. 64260.

Range.—Southern Lower California, north at least to Francisquito Bay.

Lower Californian Records.—La Paz, Yarrow, 1882*a*, p. 442; Cape St. Lucas, Yarrow, 1882, p. 57; Carmen Island, Townsend, 1890, p. 144; San José del Cabo, Espiritu Santo Island, Van Denburgh, 1895, p. 105. Santa Rosalia and San Ignacio, Mocquard, 1899, p. 306; Buena Vista, Todos Santos, Van Denburgh and Slevin, 1921*a*, p. 59.

The Albatross collections contain a sufficient series of specimens to establish the validity of this species definitely. The localities represented are: Magdalena (U. S. N. M. No. 64511); Cape San Lucas (U. S. N. M. Nos. 64512–13); San José del Cabo (U. S. N. M. No. 64505); Pichilinque Bay (A. M. N. H. Nos. 5459, 5461, U. S. N. M. Nos. 64506–10); San José Island (5439); Agua Verde Bay (5449); Carmen Island (5440–46, 5448, U. S. N. M. No. 64260); and Francisquito Bay (5452–53). In addition a fine series from Espiritu Santo Island, opposite La Paz, has been kindly loaned for study by the U. S. National Museum.

The number of dorsal scales from rump to occipital ranges from 82 to 106, the average of twenty specimens being 91. The femoral pores average 14.5 (twenty-one specimens). The most satisfactory character distinguishing the series at hand from Arizonan and New Mexican specimens is the notably greater length of the hind leg. In eighteen male specimens, this ranges from .74 to .85 of the body length, while in the northern series, the range is .65 to .79, average .71, in twenty-four male specimens examined. The average given by Richardson, who includes four specimens from southern Lower California, is .74 for twenty-three specimens.

Uta mannophorus Dickerson agrees with *elegans* in scale counts and length of hind leg; the color characters on which it is based are so closely approached in specimens of *U. elegans* and so ill defined in some paratypes of *mannophorus* that I do not think it can be maintained even as an insular race.

Van Denburgh and Slevin (1921*a*, p. 59) note the difference in habitat between *Uta elegans* in Lower California and the subspecies of *U. stansburiana* to the north. *Uta elegans* frequents the coast and was not found inland.

Uta nolascensis Van Denburgh and Slevin

Uta nolascensis Van Denburgh and Slevin, 1921*c*, p. 395.

Range.—San Pedro Nolasco Island, Gulf of California.

Uta microscutata Van Denburgh

Uta microscutata Van Denburgh, 1894, p. 298; Stejneger and Barbour, 1917, p. 50.

Uta stansburiana Mocquard, 1899, p. 306.

RANGE.—Lower California south to San José, Gulf of California.

LOWER CALIFORNIAN RECORDS.—San Pedro Martir Mts., northern Lower California, Van Denburgh, 1894, p. 298; San José Island, Gulf of California, Van Denburgh, 1895, p. 106; Santa Rosalia, San Ignacio, and Mulege, Mocquard, 1899, p. 306; San Salado Cañon, San Matias, Cañon Esperanza, Parral, San Quentin, and Rosarito, Meek, 1905, p. 10; San Xavier, Van Denburgh and Slevin, 1921*a*, p. 59.

The Albatross collection contains two specimens, one of each sex, (A. M. N. H. No. 5451, U. S. N. M. No. 64488), from Castro Rancho, Pt. Conception. The male specimen has the frontal more elongate and transversely divided, but is in every other character identical with the female, which has the normal single frontal of the species. It is evident that the specimens referred to *Uta stansburiana* by Mocquard belong to this species, since they are said to have very small dorsal scales and the frontal entire.

Uta nigricauda Cope

Uta nigricauda COPE, 1864, p. 176; STEJNEGER AND BARBOUR, 1917, p. 51.

RANGE.—Southern Lower California.

LOWER CALIFORNIAN RECORDS.—Cape St. Lucas, Cope, 1864, p. 176; La Paz, Yarrow, 1882, pp. 55, 56; Magdalena Island, San José del Cabo, Miraflores, and Sierra San Lazaro, Van Denburgh, 1895, p. 108; Todos Santos, Agua Caliente, Santiago, San Antonio, Triunfo, San Pedro, foothills of the Sierra Laguna, Van Denburgh and Slevin, 1921*a*, p. 58.

The Albatross collection contains thirty-five specimens of this species representing the following localities: Cape San Lucas (A. M. N. H. No. 5438); San Bernardo Mts. (A. M. N. H. Nos. 5471–72; U. S. N. M. No. 64494); Miraflores (A. M. N. H. Nos. 5466, 5563, 5676-91, U. S. N. M. Nos. 64495–504); Pichilinque Bay (A. M. N. H. No. 5454); and the island of Espiritu Santo, opposite La Paz, (A. M. N. H. Nos. 5463–64).

Four specimens have a divided frontal. The dorsal scaling is highly variable, on one hand approaching *Uta microscutata*, while in the other direction the enlarged dorsals are as distinct as in *Uta ornata* or *graciosa*. Thus, in A. M. N. H. No. 5690, there are only four rows of prominently enlarged dorsals; normally, there are six to eight enlarged rows; and exceptionally, the dorsals are little enlarged and pass more gradually into the smaller laterals.

Uta ornata symmetrica Baird

Uta symmetrica BAIRD, 1858, p. 253.

Uta symmetrica (part) STEJNEGER AND BARBOUR, 1917, p. 52.

Uta ornata symmetrica SCHMIDT, 1921*a*, p. 6.

RANGE.—Valley of the Colorado River and adjacent areas of the Colorado Desert.

This form is represented in the collections of the Academy of Natural Sciences of Philadelphia by two specimens (A. N. S. P. Nos. 16103–4), collected in the Cocopah Mountains of northeastern Lower California by S. N. Rhoads.

Uta auriculata Cope

Uta auriculata Cope, 1871, p. 303; Stejneger and Barbour, 1917, p. 49.

Range.—Socorro Island, Revilla Gigedo Islands, to which it is confined.

Uta clarionensis Townsend

Uta clarionensis Townsend, 1890, p. 143; Stejneger and Barbour, 1917, p. 50.

Range.—Clarion Island, Revilla Gigedo Islands, to which it is confined.

Uta graciosa (Hallowell)

Uro-saurus graciosus Hallowell, 1854, p. 92.

Uta graciosa Stejneger and Barbour, 1917, p. 50.

Range.—Southern Nevada, southeastern California, southwestern Arizona, and northeastern Lower California.

Lower Californian Records.—Santa Rosalia, Mocquard, 1899, p. 307; San Felipe, Meek, 1905, p. 10; Laguna Salada, 80 mi. south of Mexicali, Van Denburgh and Slevin, 1921*a*, p. 58.

Mocquard's identifications are not wholly reliable (see above under *Uta microscutata*) but, on analogy with *Sauromalus obesus* and *Callisaurus ventralis gabbii*, *Uta graciosa* might be expected as far south as Santa Rosalia.

Key to the Species of *Uta* in Lower California and Adjacent Islands

1. Dorsal granules very small, perfectly smooth; enlarged supraoculars in more than one row ..... 2.
   Dorsal granules less than 40 in the length of the head, at least faintly keeled posteriorly; enlarged supraoculars in one row ..... 3.
2. Caudal scales small, smooth. (Southern Lower California.) ..... *thalassina.*
   Caudal scales large, keeled, spinose. (Northern Lower California.) ..... *mearnsi.*
3. Dorsal scales nearly uniform, graduated into the smaller laterals ..... 4.
   Dorsal scales with a few median rows abruptly enlarged ..... 13.
4. Frontal entire ..... 5.
   Frontal transversely divided ..... 6.
5. Dorsal scales very small, about 35 in head length. (Northern Lower California.) *microscutata.*
   Dorsal scales larger, a broad band of enlarged scales down the back. (Southern Lower California.) ..... *nigricauda.*
6. Gular scales about 40; femoral pores 17. (San Pedro Martir Island, Gulf of California.) ..... *palmeri.*
   Gular scales less than 35; femoral pores less than 17 7

7. Hind leg short, .71 to .72 of the body length; dorsal scales very weakly keeled, very small (average 115 from rump to occipitals). (San Benito Islands, off Pacific Coast of Lower California.) ..... *stellata.*
   Hind leg more than .72 of the body length; dorsal scales sharply keeled, larger. . . 8.
8. Dorsal scales largest in the group, 70–78 from occiput to rump; hind leg .79 of the body length; femoral pores average 15. (Santa Catalina Island, Gulf of California.) ..... *squamata.*
   Dorsal scales average more than 80 ..... 9.
9. Hind leg averages .80 of the body length. (Southern Lower California.) . *elegans.*
   Hind leg averages .74 to .75 of the body length ..... 10.
10. Dorsal scales average about 86. (Southeastern California to western Texas and adjacent areas in Mexico; Angel de la Guardia Island.) *stansburiana stejnegeri.*
    Dorsal scales average more than 90 ..... 11.
11. Size large, snout to anus 62 mm. (San Martin Island, off Pacific Coast of Lower California.) ..... *martinensis.*
    Smaller, rarely exceeding 50 mm. in body length ..... 12.
12. Dorsal scales strongly keeled, average about 100; posterior femorals strongly keeled. (Southwestern California, San Joaquin Valley, and northwestern Lower California.) ..... *stansburiana hesperis.*
    Dorsal scales weakly keeled, average about 92; posterior femorals weakly keeled. (Cedros and Natividad Islands, off Pacific Coast of Lower California.) ..... *concinna.*
13. Frontal transversely divided ..... 14.
    Frontal entire. (Southern Lower California.) ..... *nigricauda.*
14. Enlarged dorsal scales nearly uniform, with no series of small scales on vertebral line; tail long, about two-thirds of total. (Southern Nevada, southeastern California, and southwestern Arizona.) ..... *graciosa.*
    One or more vertebral series of small scales ..... 15.
15. No tubercular scales forming a well defined dorsolateral line; enlarged dorsals nearly smooth; upper posterior scales on thigh smooth. (Socorro Island, Revilla Gigedo Islands.) ..... *auriculata.*
    A well-defined dorsolateral row of tubercles ..... 16.
16. Enlarged dorsals beginning on the nape; dorsolateral tubercles very large, close set. (Clarion Island, Revilla Gigedo Islands.) ..... *clarionensis.*
    Enlarged dorsals beginning on the shoulders, dorsolateral tubercles smaller and more widely spaced. (The Colorado Desert.) ..... *ornata symmetrica.*

Uta nolascensis is not entered in the above key, information on its "key characters" being insufficient. It should apparently be placed next to *Uta stansburiana stejnegeri.*

Sceloporus occidentalis bi-seriatus Hallowell

Sceloporus bi-seriatus Hallowell, 1854, p. 93.

Sceloporus occidentalis bi-seriatus Stejneger and Barbour, 1917, p. 55.

Range.—The Great Basin, south to Texas and California.

Lower Californian Records.—San Pedro Martir Mt., and Valladares, Van Denburgh, 1895, p. 114; between Ensenada and San Rafael Valley, and San Telmo, Van Denburgh, 1896, p. 1005; Santo Tomas and Los Encinos, Meek, 1905, p. 11 (Heller's notes); Ensenada, Van Denburgh and Slevin, 1921*a*, p. 59.

Specimens in the Biological Survey collection come from Hanson Laguna (U. S. N. M. No. 37674) and Ojos Negros (37677–8).

Sceloporus graciosus vandenburgianus Cope

Sceloporus vandenburgianus Cope, 1896, p. 834.

Sceloporus graciosus vandenburgianus Stejneger and Barbour, 1917, p. 54.

Range.—Mountain ranges south of Ventura County, California, into northern Lower California.

Lower Californian Records.—San Pedro Martir Mt., Van Denburgh, 1895, p. 114; Agua de las Fresas, Vallecitos, and La Grulla, Meek, 1905, p. 11.

A specimen in the Biological Survey collection comes from La Grulla (U. S. N. M. No. 37673).

Sceloporus magister Hallowell

Sceloporus magister Hallowell, 1854, p. 93; Stejneger and Barbour, 1917, p. 55.

Range.—Southern Nevada, southwestern Utah, southeastern California, southwestern Arizona, northwestern Lower California.

Lower Californian Records.—Gardner's Laguna, Salton River, Cope, 1900, p. 361.

Specimens in the Biological Survey collection come from Volcano Lake (U. S. N. M. Nos. 37659–60), Cocopah Mts., east base (37663), and San Felipe Bay (37664).

Sceloporus rufidorsum Yarrow

Sceloporus rufidorsum Yarrow, 1882*a*, p. 442; Van Denburgh and Slevin, 1921*a*, p. 60.

Range.—Northwestern Lower California to Cedros Island.

Lower Californian Records.—75 miles S. E. of San Diego, Lockington, 1880, p. 295; San Quentin Bay and Cedros Island, Yarrow, 1882*a*, p. 442; San José, Matomi, Rosarito, and San Quentin, Meek, 1905, p. 11; Ensenada, Van Denburgh and Slevin, 1921*a*, p. 60.

Specimens in the Biological Survey collection come from Ensenada (U. S. N. M. Nos. 37661–2).

Three specimens of this species from Cedros Island (A. M. N. H. Nos. 5474, 5476, U. S. N. M. No. 64473) bear out the remarks of Van Denburgh (*loc. cit.*) in distinguishing *rufidorsum* from *zosteromus*, especially in the presence of a broad mid-dorsal rufous band and similar indistinct dorsolateral lines, and in the larger size as compared with *zosteromus* from the Cape Region.

Sceloporus zosteromus Cope

Sceloporus zosteromus Cope, 1863, p. 105; Stejneger and Barbour, 1917, p. 57.

Range.—Southern and central Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1863, p. 105; La Paz, Yarrow, 1882*a*, p. 442; San Pablo, Magdalena Island, Santa Margarita Island,

San José Island, Miraflores and San José del Cabo, Van Denburgh, 1895, p. 110; Mulege and San Ignacio, Mocquard, 1899, p. 313; Todos Santos, Agua Caliente, Buena Vista, San Antonio and San Pedro, Van Denburgh and Slevin, 1921*a*, p. 60.

Specimens in the Biological Survey collection come from San Ignacio (U. S N. M. Nos. 37666–9), Santa Anita (37671), and Cape San Lucas (37672).

Twelve specimens of this species were secured in the Cape Region of Lower California by the Albatross Expedition. The localities represented are: Cape San Lucas (A. M. N. H. Nos. 5437, 5473); San José del Cabo (U. S. N. M. Nos. 64468–71); Miraflores (5484, 5489, U. S. N. M. Nos. 64466–7); Espiritu Santo Island (5486).

Sceloporus lineatulus Dickerson

Sceloporus lineatulus Dickerson, 1919, p. 467.[1]

Range.—Santa Catalina Island, Gulf of California.

Two specimens collected by the Albatross Expedition on Santa Catalina Island were distinguished from *S. zosteromus* by Dickerson on the basis chiefly of the strongly lineate lateral scales. In this character, the single paratype (A. M. N. H. No. 5477) agrees excellently with the type, each scale bearing two sharply defined brown lines, which combine to form very irregular, curved lines extending from the black throat patch nearly as far back as the groin. This specimen measures 96 mm. from snout to vent, thus considerably exceeding the average for the peninsular *zosteromus*. The ventral color in both specimens is dark blue without the broad light mid-ventral band common in *S. zosteromus*. I do not find any distinctive characters in addition to size and coloration, and Van Denburgh and Slevin (1921, p. 60) refer to lineate lateral scales as a character of adult male *zosteromus*. I prefer, however, to maintain *lineatulus* as distinct until further evidence bearing on the question is available.

Sceloporus monserratensis Van Denburgh and Slevin

Sceloporus monserratensis Van Denburgh and Slevin, 1921*c*, p. 396.

Range.—Monserrate Island, Gulf of California.

Sceloporus orcutti Stejneger

Sceloporus orcutti Stejneger, 1893, p. 181, Pl. I, fig. 4; Stejneger and Barbour, 1917, p. 56.

Range.—Northern Lower California and southern California.

Lower Californian Records.—San Rafael Valley, Wasson's Ranch (in San Rafael Valley), between Ensenada and Rafael Valley, and in the foothills of the San Pedro Martir Mts., Van Denburgh, 1896, p. 1005; Nochoguero Valley near U. S.

[1]Type: U. S. N. M. No. 64263.

boundary, Cope, 1900, p. 356; San Salado Cañon, Trinidad, San Matias, Agua de la Fresas, Cañon Esperanza, Parral, Matomi, Rosarito, San Antonio, and Los Encinos, Meek, 1905, p. 11; San Xavier, Van Denburgh and Slevin, 1921*a*, p. 61.

Specimens in the Biological Survey collection come from Ojos Negros (U. S. N. M. Nos. 37675–6) and Rancho San Antonio (37665).

Sceloporus licki Van Denburgh

Sceloporus licki Van Denburgh, 1895, p. 110, Pl. x; Stejneger and Barbour, 1917, p. 54.

Range.—Southern Lower California.

Lower Californian Records.—San José del Cabo, Corral de Piedras (Sierra El Taste), Miraflores, and Sierra San Lazaro, Van Denburgh, 1895, p. 114; San Antonio, Todos Santos, Guamuchil Ranch, Cape San Lucas, Agua Caliente, San Bartolo, Triunfo, and La Paz, Van Denburgh and Slevin, 1921*a*, p. 61.

The Albatross Expedition contains six specimens referable to this species; the localities represented are Miraflores, (A. M. N. H. Nos. 5564, 5669, 5702, U. S. N. M. No. 64472); San Bernardo Mts., (5487); and Espiritu Santo Island, (5485).

A specimen in the Biological Survey collection comes from Espiritu Santo Island (U. S. N. M. No. 37670).

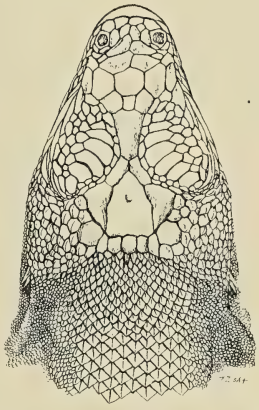

Fig. 8. Dorsal view of the head of the type of *Sator grandævus* Dickerson, U. S. N. M. No. 64261.

Key to the Species of *Sceloporus* in Lower California

1. Enlarged supraoculars separated from the parietal and frontoparietal scales by a semicircle of small scales ..... 2.
   Enlarged supraoculars in contact with the parietals and frontoparietals ..... 3.
2. Dorsal scales small, 45–66 on middle of back from occipital to base of tail; scales on back of thigh smooth ..... *S. graciosus vandenburgianus.*
   Dorsal scales larger, 35–46, scales on back of thigh keeled; males with a blue patch on center of throat ..... *S. occidentalis biseriatus.*
3. Dorsal scales shortly mucronate, the central point scarcely extending beyond the lateral; no black patch in front of shoulder ..... *S. orcutti.*
   Dorsal scales sharply mucronate; a black patch in front of shoulder ..... 4.
4. Femoral pores usually less than 14, average 12 on each side ..... *S. magister.*
   Femoral pores usually more than 14, average 16 or more ..... 5.
5. Dorsal scales from occipital to base of tail more than 30 (32–38) ..... *S. licki.*
   Dorsal scales 30 or less (28–30) ..... 6.
6. Femoral pores fewer, average 16.6; back with mid-dorsal and dorsolateral light bands ..... *S. rufidorsum.*
   Femoral pores more numerous, average 18.5; dorsolateral and mid-dorsal bands not evident ..... *S. zosteromus.*

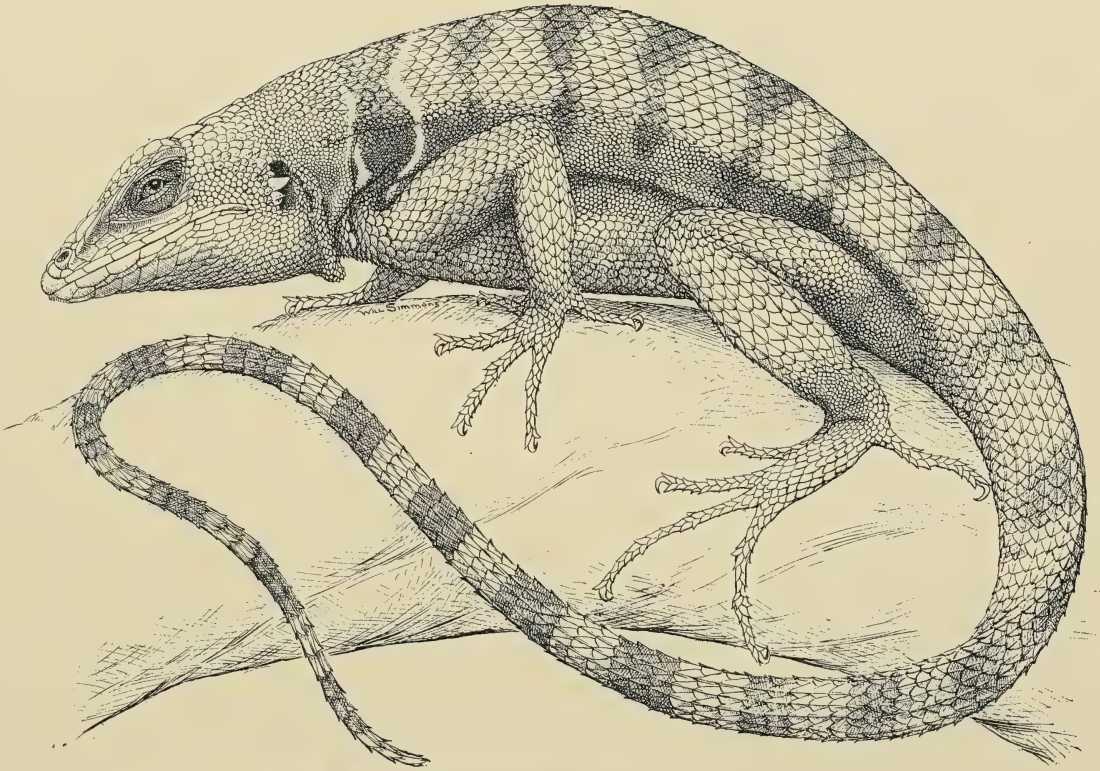

Fig. 9. *Sator grandævus* Dickerson, A. M. N. H. No. 5492.

Sator grandævus Dickerson

Sator grandævus Dickerson, 1919, p. 469.[1]

Range.—Ceralvo Island, Gulf of California.

This species and the following are certainly closely related to *Sceloporus* through *S. utiformis* of the Coliman region in Mexico and are much more closely allied to *Sceloporus* than to *Uta*. The development of the gular fold and the rudiment of a collar illustrate excellently an intermediate stage between *Sceloporus* with differentiated dorsal and lateral scales and a *Uta* of the *Uta nigricauda* type; but it is not at all necessary to assume that *Sator* is the direct representative of the ancestral *Utas*, which I believe to have been very different from *Sceloporus*. The gular fold being more strongly developed than in *Uta*, and the collar less developed, it may well be that both are parallel structures and that the species of *Sator* have arisen independently from a *Sceloporus* stock related to *S. utiformis*. The three genera *Sceloporus*, *Sator*, and *Uta* form a group of North American iguanid genera much like that formed by *Callisaurus*, *Uma* and *Holbrookia*.

The distribution of the two insular species of *Sator*, on widely separated islands off the Gulf coast of the peninsula, suggests that the genus must formerly have inhabited the mainland of the peninsula, where it is now almost certainly extinct.

Sator angustus Dickerson

Sator angustus Dickerson, 1919, p. 469.[2]

Range.—Santa Cruz Island, Gulf of California.

The measurements of the type of this species are, unfortunately, placed after those of *Sator grandævus* in the original description. The anterior gular folds in this species is much more definitely marked by differentiation of the scales than it is in *grandævus*. In the latter, the fold is marked by an abrupt transition in size of the gular scales, which are about twice as wide behind the fold as the scales in the series anterior to it. In *angustus*, a double row of granular scales, much smaller than those on the fold, crosses the throat immediately behind the fold, which thus becomes very similar to the collar of other genera, but is not a homologous structure. In *Sator grandævus*, there is a distinct lateral invasion of granules in the position of the posterior gular fold, i.e., an incipient collar homologous with the collar of *Uta*. In *angustus*, there

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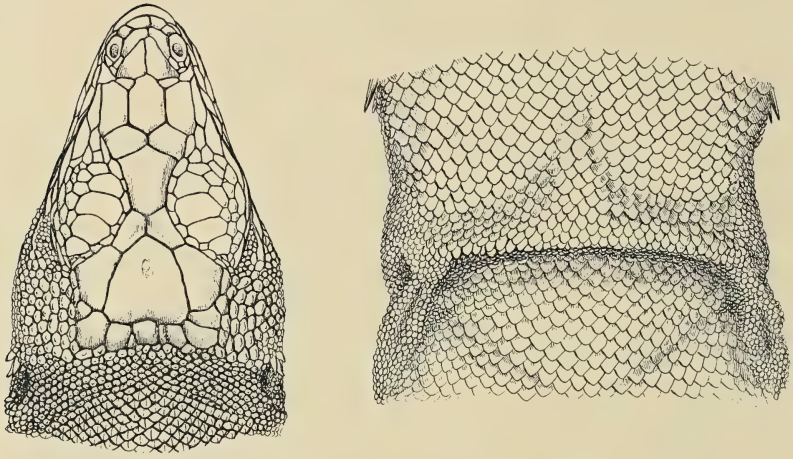
[1]Type: U. S. N. M. No. 64261.

[2]Type: U. S. N. M. No. 64262. Paratypes: U. S. N. M. Nos. 64474–78; A. M. N. H. Nos. 5713–16, 5719, 5722.



A *B*

Fig. 10. *A*, Dorsal view of head of *Sator angustus* Dickerson, A. M. N. H. No. 5716. × 2.5 *B*, Throat of type of *Sator angustus*, to show differentiation of scales at the gular fold, U. S. N. M. No. 64262. × 3.

is no trace of the posterior fold or incipient collar, and the better development of the anterior fold may be correlated with this fact.

Phrynosoma blainvillii blainvillii Gray

Plate LIV, Figure 2

Phrynosoma blainvillii Gray, 1839, p. 96, Pl. xxix, fig. 1; Stejneger and Barbour, 1917, p. 57.

Phrynosoma blainvillii blainvillii Grinnell and Camp, 1917, p. 164.

Range.—Southwestern California and northwestern Lower California.

Lower Californian Records.—Valladares, Van Denburgh, 1895, p. 118; Ensenada, San Telmo, Wasson's Ranch in San Rafael Valley, Van Denburgh, 1896, p. 1005; Nochoguero Valley, United States boundary, Cope, 1900, p. 427; San Salado and Trinidad, Meek, 1905, p. 12; Ensenada, Van Denburgh and Slevin, 1921*a*, p. 62.

A specimen in the Biological Survey collection comes from Ojos Negros (U. S. N. M. No. 37583).

Phrynosoma nelsoni,[1] new species

Plate LIV, Figure 3

Phrynosoma coronatum (*non* Blainville) Meek, 1905, p. 12.

Diagnostic Characters.—Two lateral fringes of elongate scales; enlarged gulars present; nostrils on the canthus rostralis; ventral scales smooth; temporal and occipital horns well developed; a large subrictal spine, followed by a postrictal; tympanum nearly concealed by folds of the neck; closely allied to *P. blainvillii blainvillii*, from which it is distinguished by the smaller and rugose scales of the top of the head, the fewer enlarged dorsal scales, and the larger and more strongly keeled scales of the vertebral line.

[1]Named for Dr. Edward W. Nelson, Chief, Bureau of Biological Survey, United States Department of Agriculture, whose explorations in Lower California make this name especially appropriate.

Range.—Known only from the type locality.

Type.—U. S. N. M. No. 37585; ♀; San Quintin, Lower California; E. W. Nelson and A. E. Goldman; August 15, 1905. (Biological Survey Collection.)

Description of Type.—Habitus stout, apparently wider in proportion to length than *P. blainvillii;* tail round; tympanum nearly concealed by the folds of the neck; nostril just below the canthus rostralis; superciliary region expanded; a series of four temporal spines, the last largest and nearly equalling the occipital; two strong occipital spines with a smaller median spine nearly in line with them; all somewhat grooved basally; scales of front very rugose, much smaller than in *b. blainvillii,* larger than those of *b. frontale;* no connecting ridge between the superciliary angles; a transverse series of four conical spines in front of the occipitals; six infralabials, the fifth largest, the last (very small) beneath the anterior side of the subrictal; a strong subrictal above the line of the infralabial spines, followed by a smaller, pointed spine (the postrictal) in the line of the infralabials; two lateral groups of spines on the neck; three rows of enlarged gulars on each side; eight or ten irregular rows of large keeled scales on the back, continuing as a lateral and a dorsolateral series on the tail; vertebral line covered with enlarged, flat, keeled scales; strong spinose scales on the thighs, two well-marked series of elongate lateral scales forming a double marginal fringe; ventral scales flat, smooth; femoral pores 15–16.

Grayish above, with four pairs of obscure transverse brown blotches on the back, corresponding in position to the larger of the enlarged dorsal scales; two brown crossbands on base of tail; venter grayish, spotted with brown posteriorly.

Measurements of Type.—Total length, 127 mm.; body, 87 mm.; tail, 40 mm.; foreleg, 38 mm.; hind leg, 51 mm.; snout to tip of temporal horn, 29 mm.; greatest width of head (between tips of third temporal horns), 31 mm.

Notes on Paratypes.—The smaller male paratype, U. S. N. M. No. 37584, from the same locality, has a narrower body, and only five infralabials, but agrees in essential characters with the type. A third specimen in the series before me, Field Museum No. 1127, a female, recorded by Meek as *P. coronatum* (*loc. cit*), thus recognizing its distinctness from *P. blainvillii,* has the tympanum completely concealed by the neck folds. The measurements of the two paratypes are as follows:

Number	U. S. N. M. No. 37584	F. M. No. 1127
Total Length	110 mm.	122 mm.
Length of Body	73 "	88 "
Length of Tail	37 "	34 "
Length of Foreleg	34 "	38 "
Length of Hind Leg	43 "	51 "
Greatest Width of Head	27 "	31 "

I have no doubt that this species is fully distinct from *P. blainvillii blainvillii,* which is unquestionably the most closely allied species. Its relationship with *P. blainvillii frontale,* shown in the rugosity of the frontal scales, appears to be closer than with the typical subspecies, although the range of the latter is inserted between that of *nelsoni* and *frontale.* From *frontale* it is distinguished by the larger frontal scales and the keeled scales of the vertebral line. *Phrynosoma coronatum* has much

larger scales on the frontal region of the head, a more fully exposed tympanum, stronger and much more divergent occipital spines, and is immediately distinguishable from *nelsoni* by the absence of a postrictal spine.

Phrynosoma schmidti Barbour

Phrynosoma schmidti Barbour, 1921, Proc. New England Zoöl. Club, VII, p. 113.

Range.—Confined to Cedros Island.

Phrynosoma jamesi,[1] new species

Plates LV and LVI

Diagnostic Characters.—Closely allied to *Phrynosoma cerroense* Stejneger, from which it is distinguished chiefly by the presence of a ventral lateral fringe; enlarged gulars present; nostrils very large, just below the canthus rostralis; ventrals smooth; temporal and occipital horns well developed; a large subrictal nearly in line with the labial spines, followed by a slender postrictal spine; tympanum not concealed.

Range.—Known only from the type locality.

Type.—U. S. N. M. No. 64450; ♀; San Bartolome Bay, Lower California; H. Townsend; 1911.

Description of Type.—Habitus rather narrow, probably similar to that of *P. cerroense;* head small, snout very obtuse, truncate in profile; tail round; nostril very large, just below the line of the canthus rostralis; ear opening not closed; superciliary angle not produced; temporal region little expanded, with four spines, of which the two middle ones are in contact; the last temporal spine about half the length of the occipital; two occipitals, straight, somewhat grooved at the base; a low tubercular spine between the occipitals; scales of front smaller than in *helleri* or *coronatum*, rugose; no connecting ridge between the superciliary angles; a transverse series of four low conical scales in front of the occipital spines; five infralabials, the last largest, followed after an interspace by the somewhat larger subrictal, which is very nearly in line with the labials; a small, slender postrictal spine; two lateral groups of tubercular scales on the neck, but no spines; three or four rows of enlarged gulars on each side; irregular rows of widely separated, flat, keeled scales on the back; vertebral line covered with smaller, flat, keeled scales; tail with two dorsal rows of spines and a lateral row on each side; two lateral fringes of spinose scales, the lower one much smaller than the upper; ventral scales flat, smooth; femoral pores 17–17.

Grayish above, with two obscure nuchal marks; venter with a few scattered brown spots.

Measurements of Type.—Total length, 120 mm.; body, 86 mm.; tail, 34 mm.; foreleg, 34 mm.; hind leg, 46 mm.; snout to tip of occipital horn, 24 mm.; greatest breadth of head, 24 mm.

Notes on Paratypes.—The single paratype, A. M. N. H. No. 5497, agrees excellently with the type; the last temporal spines are somewhat longer, and are curved upward. The back is marked with large brown spots, two elongate nuchal spots, a transverse series of four spots behind these, with two pairs of more obscure spots between these and the base of the tail.

[1]Named for Mr. Arthur Curtiss James, Trustee of The American Museum of Natural History.

The close relation of this species to *P. cerroense*, its nearest neighbor geographically, is especially evident in the arrangement of the spines of the head; from the figure of the type of *cerroense* it appears that *jamesi* has a much more truncate muzzle. The two are readily distinguishable by the absence of the ventral lateral fringe in *cerroense*.

As *cerroense* was considered intermediate between *blainvillii* and *coronatum* by Stejneger (1893, p. 187) and Cope (1900, p. 430), it is evident that the present form, with its two lateral fringes, is much more nearly intermediate between them and that *cerroense* is to be regarded as divergent from a stock similar to *jamesi*. Our knowledge of the distribution of the four Lower Californian species, *blainvillii*, *nelsoni*, *jamesi*, and *coronatum* is very inadequate. It is not at all unlikely that *nelsoni* may prove to be a third subspecies of *blainvillii*. *P. jamesi* and *coronatum*, however, appear to be sufficiently distinct to preclude any possibility of their intergradation. It would be highly interesting to know if the species of *Phrynosoma* in Lower California really have a restricted distribution, with wide areas where they are absent, as might be inferred from the present information regarding them.

Phrynosoma cerroense Stejneger

Phrynosoma cerroense Stejneger, 1893, p. 187; Stejneger and Barbour, 1917, p. 58.

Range.—Confined to Cedros Island, off the Pacific coast of Lower California.

Phrynosoma coronatum (Blainville)

Plate LIV, Figure 1

Agama (Phrynosoma) coronatum Blainville, 1835, p. 284, Pl. xxv, fig. 1.

Phrynosoma coronatum Stejneger and Barbour, 1917, p. 58.

Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1866*a*, p. 312; La Paz, Yarrow, 1882, pp. 67–68; Comondu to San Quentin, Poso Grande, San José del Cabo, San Francisquito (Sierra Laguna), and Miraflores, Van Denburgh, 1895, p. 115; Santa Anita, McLain, 1899, p. 2; Santa Rosalia, San Ignacio, and Mulege, Mocquard, 1899, p. 314; Todos Santos, Pescadero, Agua Caliente, Triunfo, and San Pedro, Van Denburgh and Slevin, 1921*a*, p. 62.

Three specimens of *P. coronatum* were secured by the Albatross Expedition, from Miraflores (A. M. N. H. Nos. 5499, 5701) and San José del Cabo (U. S. N. M. No. 64465). A fourth is contained in a small collection with the general locality "La Paz" received from the Museo Nacional de Mexico.

Five specimens in the Biological Survey collection come from Matancita (U. S. N. M. Nos. 37586–90).

Phrynosoma platyrhinos Girard

Phrynosoma platyrhinos Girard, 1852, pp. 361, 363, Pl. vii, figs. 1–5; Stejneger and Barbour, 1917, p. 60.

Range.—Washington and Idaho, south through Utah and Nevada to southeastern California, northeastern Lower California and southwestern Arizona.

Lower Californian Records.—San Felipe, Meek, 1905, p. 12.

A specimen in the Biological Survey collection comes from Pozo San Augustin (U. S. N. M. No. 35791). This locality extends the range of this form considerably to the south, the only previous record from Lower California being that of Meek from San Felipe Bay.

Phrynosoma solare Gray

Phrynosoma solaris Gray, 1845, p. 229.

Phrynosoma solare Stejneger and Barbour, 1917, p. 60.

Range.—Northeastern Lower California, southwestern Arizona and Sonora.

Lower Californian Records.—Las Animas Bay, Van Denburgh, 1894*b*, p. 456.

The distribution of *P. solare* is remarkable for the wide gap between the Lower Californian record (opposite Angel de la Guardia Island) and the area of relative abundance of this species at the border of the Mexican Plateau in Arizona. It appears to be absent from the Colorado Desert, and thus forms one of the best examples of what I have called attention to (above) as peripheral distribution, bordering the Colorado Desert.

Key to the Species of *Phrynosoma* in Lower California

1. A single marginal (lateral) fringe of elongate scales ..... 2.
   Two or three complete marginal fringes ..... 3.
2. Nostrils within the lines of the canthi rostrales ..... *P. platyrhinos.*
   Nostrils on the lines of the canthi rostrales ..... *P. cerroense.*
3. Three closely set lateral fringes; tail flattened. (Not recorded from Lower California, but probably entering the northeastern area.) ..... *P. m'callii.*
   Two lateral fringes; tail round distally ..... 4.
4. Four large subequal occipital spines in line with the temporals ..... *P. solare.*
   Occipital spines unequal, not in line with the temporals ..... 5.
5. Subrictal spine broadly expanded at base, its anterior border overlapping the last spine of the sublabial series ..... 6.
   Subrictal not overlapping the last of the sublabials, nearly in line with them ... 7.
6. Scales of mid-dorsal line keeled, pointed and strongly imbricate; scales of front rugose ..... *P. nelsoni.*
   Scales of vertebral line smaller, rounded and less imbricate; scales of front convex and smooth ..... *P. blainvillii blainvillii.*
7. No slender elongate postrictal spine ..... *P. coronatum.*
   A slender elongate postrictal spine, about as long as the subrictal ..... 8.
8. Lower of the two lateral fringes weak; occipital spines slender ..... *P. jamesi.*
   Lower lateral fringe strongly developed; occipital spines short and stout. *P. schmidti.*

Gerrhonotus scincicauda webbii Baird

Gerrhonotus webbii Baird, 1858, p. 255.
Gerrhonotus scincicauda webbii, Grinnell and Camp, 1917, p. 168.

Range.—Southwestern California, chiefly west of the desert divides, north to Mariposa County, south into northwestern Lower California.

Lower Californian Records.—Coronados Islands, Belding, 1887, p. 97; Valladares and San Pedro Martir Mt., Van Denburgh, 1895, p. 121; San Antonio, Meek, 1905, p. 12; San Martin Island, Van Denburgh, 1905, p. 19.

Specimens in the Biological Survey collection come from Rancho San Antonio (U. S. N. M. No. 37681) and Hanson Laguna (37682).

Gerrhonotus multi-carinatus (Blainville)

Cordylus (*Gerrhonotus*) *multi-carinatus* Blainville, 1835, p. 289, Pl. xxv, fig. 2.
Gerrhonotus multi-carinatus Stejneger and Barbour, 1917, p. 61.

Range.—Lower California and Mexico.

Lower Californian Records.—La Paz, Yarrow, 1882, p. 47; San José del Cabo, Corral de Piedras (Sierra El Taste), Sierra San Lazaro, Miraflores, and Sierra Laguna, Van Denburgh, 1895, p. 120.

Three specimens in the Biological Survey collection come from Santa Anita (U. S. N. M. Nos. 37683–5). This species has been excellently characterized by Van Denburgh (1898, p. 65). In addition to the characters employed by him, it may be noted that the limbs are much weaker and the body and tail more elongate than in *G. scincicauda webbii*. The proportions of arm and leg to body length in two specimens of each species are as follows:

	G. multi-carinatus	*G. s. webbii*
Arm/Body Length	.19, .23	.25, .27
Leg/Body Length	.27, .29	.35, .36

Key to Distinguish the Species of *Gerrhonotus* in Lower California[1]

Dorsal scales usually in 16 rows, weakly keeled.....*G. multi-carinatus.*
Dorsal scales usually in 14 rows, strongly keeled.....*G. scincicauda webbii.*

Anniella pulchra Gray

Anniella pulchra Gray, 1852, p. 440; Stejneger and Barbour, 1917, p. 63.

Range.—Coastal Region of southern California and northern Lower California.

Lower Californian Records.—San Salado Cañon, San José, Meek, 1905, p. 13; Coronados Islands, San Geronimo Island, Van Denburgh and Slevin, 1914, pp. 140, 142.

Xantusia vigilis Baird

Xantusia vigilis Baird, 1858, p. 255; Stejneger and Barbour, 1917, p. 64.

Range.—Southeastern California, southern Nevada, and northeastern Lower California.

Lower Californian Records.—San Matias Pass, Heller, in Meek, 1905, p. 13.

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[1]After Van Denburgh, 1898, p. 64.

A specimen in the Biological Survey collection comes from San Felipe Bay (U. S. N. M. No. 37679).

Xantusia gilberti Van Denburgh

Xantusia gilberti Van Denburgh, 1895, p. 121, Pl. xi; Stejneger and Barbour, 1917, p. 64.

Range.—Southern Lower California.

Lower Californian Records.—San Francisquito, Sierra Laguna, Van Denburgh, 1895, p. 121.

A specimen in the Biological Survey collection comes from Laguna, Sierra Laguna (U. S. N. M. No. 37680). This specimen is of great interest, proving that *X. gilberti* is very closely related to *vigilis* and that some of the distinctive characters of the type were abnormal. In the type, the frontal is divided, and in contact with the interfrontonasal. In the present specimen, the head shields are disposed exactly as in *vigilis*, the prefrontals meeting in the mid-line in front of the single frontal. The head shields differ from those of *vigilis*, however, in being flatter and smoother. The head is smaller, the nose more pointed, and the eye smaller. In addition to the smallness of the eye, this specimen agrees with *X. gilberti* in the disposition of the postmentals, the second pair being separated by a narrow scale, as figured by Van Denburgh (1895, Pl. xi, fig. D). In *vigilis*, this median scale is much broader. There is no question, therefore, of the validity of *gilberti*, though its diagnosis must be changed.

In two specimens of *vigilis* from Lane's Mill, California, collected by Heller in 1903 and preserved in the Field Museum of Natural History, the frontal is completely divided, as in the type of *gilberti*. In another specimen in the same series the frontal is in contact with the interparietal.

The back of the present specimen of *gilberti* is nearly uniform brown, with scarcely any of the darker brown maculation of *vigilis*.

Key to Distinguish the Species of *Xantusia* in Lower California

Second pair of postmentals widely separated; eye larger; back maculate or lineolate with dark brown spots ..... *X. vigilis.*

Second pair of postmentals narrowly separated; eye smaller; back nearly uniform in color ..... *X. gilberti.*

Cnemidophorus tessellatus tessellatus (Say)

Ameiva tessellata Say, 1823, p. 50.

Cnemidophorus tessellatus tessellatus Stejneger and Barbour, 1917, p. 67.

Range.—Texas to California, the Great Basin; entering northeastern Lower California.

Lower Californian Records.—San Felipe, Meek, 1905, p. 14.

Van Denburgh lists this species as probably entering northeastern Lower California but not yet definitely recorded from the peninsula. It seems highly probable that the specimen recorded by Meek as *C. stejnegeri* from San Felipe, on the Gulf side of the peninsula, should be placed here.

I have referred specimens in the Biological Survey collection from Cocopah Mts., east base (U. S. N. M. Nos. 37693–4), San Felipe Bay (37690), and Poso Altamirano (37696) to this subspecies. The specimen from Poso Altamirano, near the center of the peninsula, differs slightly in coloration and in having smaller antebrachials from the typical *tessellatus*. It seems best, however, to place it with this species, pending the accumulation of further data.

Cnemidophorus tessellatus stejnegeri Van Denburgh

Cnemidophorus stejnegeri Van Denburgh, 1894, p. 300.

Cnemidophorus tessellatus stejnegeri Stejneger and Barbour, 1917, p. 68.

Range.—Coastal district of southern California and northern Lower California.

Lower Californian Records.—Near Ensenada, San Telmo, foothills of San Pedro Martir Mts., Van Denburgh, 1894, p. 300; "Comondu to San Quentin," Van Denburgh, 1895, p. 126; San Fernando, Cope, 1900, p. 599; Trinidad, San Matias, Cañon Esperanza, San Antonio, Parral, Matomi, Rosarito, Aguas Escondito, Meek, 1905, p. 14.

A specimen in the Biological Survey collection comes from Ojos Negros (U. S. N. M. No. 37689).

Cnemidophorus bartolomas Dickerson

Cnemidophorus bartolomas Dickerson, 1919, p. 476.

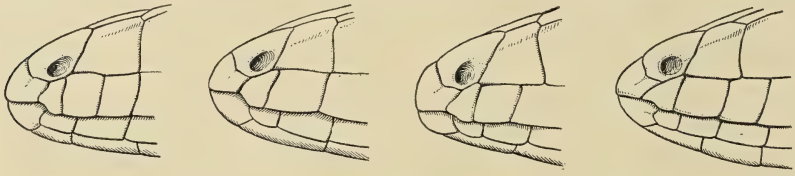
Range.—San Bartolome Bay, Lower California.

Lower Californian Records.—San Bartolome Bay, Abreojos Point, Dickerson, 1919, p. 476.[1]

The four specimens of this form brought back by the Albatross Expedition are of considerable interest for the variations they exhibit. In two specimens, the nasal is in contact with the second labial on one side, separated from it on the other; in one case, just touching; in the other, more broadly in contact. In two specimens, there are only two complete rows of enlarged antebrachials; in the others, there are three complete rows. In coloration, one specimen, No. 5522, from the more southern locality, Abreojos Point, approaches *C. rubidus* in the distinctness and wide separation of the black spots. The remaining three are fully adult specimens, the spots somewhat smaller and less sharply defined.

[1]Type: U. S. N. M. No. 64448.

In the variation of the antebrachials and of the second labial, these specimens show an approach to *C. labialis* Stejneger, which is amply distinguished, however, by other characters (single posterior anal plate, low number of femoral pores and coloration). I believe that *C. bartolomas* is directly related to *C. tessellatus stejnegeri*, and that it is derived from that form. It seems amply distinct in the character of the throat scales described in the key. *C. multiscutatus* is somewhat less distinct from *C. tessellatus stejnegeri* in coloration and in other characters than *C. bartolomas*. It is evident that for an adequate revision of the Lower Californian *Cnemidophorus* much additional material is needed.



A *B* *C* *D*

Fig. 11. Variation in the labials of *Cnemidophorus bartolomas* Dickerson. *A*, Type, U. S. N. M. No. 64448, left side, nasal in contact with second labial; *B*, same specimen, right side (reversed in figure) nasal not in contact with second labial; *C*, A. M. N. H. No. 5507, and *D*, A. M. N. H. No. 5522, showing different degrees of separation of nasal and second labial.

Cnemidophorus multiscutatus Cope

Cnemidophorus tessellatus multiscutatus Cope, 1892*a*, p. 38.

Cnemidophorus multiscutatus Stejneger and Barbour, 1917, p. 66.

Range.—Cedros Island, off the Pacific Coast of Lower California.

Three specimens (A. M. N. H. Nos. 5505–6, U. S. N. M. No. 64462) were collected on Cedros Island by the Albatross Expedition. They do not differ in any important respect from the description of Cope (1900, p. 586).

Cnemidophorus rubidus Cope

Cnemidophorus tessellatus rubidus Cope, 1892*a*, p. 36, Pl. xii, fig. *f*.

Cnemidophorus rubidus Stejneger and Barbour, 1917, p. 67.

Range.—Santa Margarita and Magdalena Islands, Pacific coast of Lower California.

Lower Californian Records.—Santa Margarita Island, Cope, 1892*a*, p. 36; Magdalena Island, Comondu, Van Denburgh, 1895, p. 126.

A single specimen of this species was collected by the Albatross Expedition on Santa Margarita Island (U. S. N. M. No. 64463).

Cnemidophorus labialis Stejneger

Cnemidophorus labialis Stejneger 1890, p. 643; Stejneger and Barbour, 1917, p. 66.

Range.—Confined to Cedros Island.

Cnemidophorus vandenburghi Dickerson

Cnemidophorus vandenburghi Dickerson, 1919, p. 477.[1]

Range.—Carmen Island, Gulf of California.

The single specimen (U. S. N. M. No. 64449), collected by the Albatross Expedition, on which this species is based appears to be sufficiently distinct from any peninsular *Cnemidophorus* or from *C. celeripes* on San José Island. Although much smaller in size than the specimens of *celeripes*, the color pattern represents the end stage of the usual *tessellatus* development, being distinguished further by an unusually fine division of the residual black spotting.

Cnemidophorus celeripes Dickerson

Plate LVII

Cnemidophorus celeripes Dickerson, 1919, p. 472.[2]

Range.—San José Island, Gulf of California.

Two specimens of a *Cnemidophorus* were collected on San José Island by the Albatross Expedition. Aside from the species related to *C. martyris* Stejneger, they certainly represent the most distinct of the insular species of this genus in the Gulf of California, being readily distinguishable from the remaining Lower Californian species of the *tessellatus* group by their retention of sharply defined black lines in the adult phase of coloration.

Dickerson (*loc. cit.*) has tentatively referred the *Cnemidophorus grahami* recorded from Santa Rosalia and Mulege by Mocquard (1899, p. 315) to this form. In the examination of the Gulf insular faunas which I have been able to make, it appears that the San José species are in general more distinct from the peninsular forms than are those on Carmen Island, the latter being frequently identical with those on the mainland. It is, therefore, more probable that Mocquard's *C. grahami*, and probably his *C. sexlineatus* from Santa Rosalia as well, are *C. vandenburghi*. This question must await the evidence of further collections, which are urgently needed from the whole of the Gulf side of the peninsula north of La Paz. It is not improbable that *C. maximus* will be discovered in this area when it is more fully explored.

Cnemidophorus estebanensis Dickerson

Cnemidophorus estebanensis Dickerson, 1919, p. 474.[3]

Range.—Confined to San Esteban Island, Gulf of California.

The single *Cnemidophorus* collected by the Albatross Expedition on San Esteban Island is the type of this species. It is certainly well dis-

[1]Type: U. S. N. M. No. 64449.
[2]Type: U. S. N. M. No. 64444.
[3]Type: U. S. N. M. No. 64446.

tinguished from *C. punctilinealis* Dickerson from Tiburon Island by the much longer head and neck, and the smaller size. The scales of the under surface of the forearm are not notably different from those of *punctilinealis*. The femoral pores number 22–23.

The differences cited in the original description to distinguish *estebanensis* from *melanostethus* are inadequate, and I am unable to find other characters of greater weight. The coloration appears to be practically identical. I have, nevertheless, retained *C. estebanensis* in the present list, as it is not improbable that the examination of series of specimens will justify its retention as an insular race. On the other hand, the examination of adequate material of this form and its near relatives on the neighboring islands may quite as probably disprove their supposed distinctness.

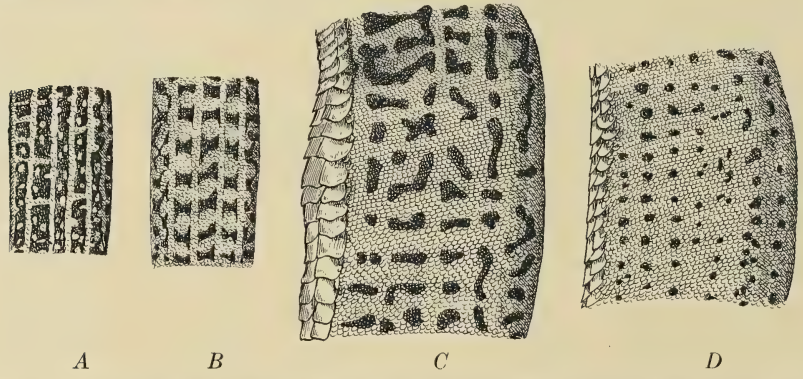


Fig. 12. Stages in the development of the color pattern of *Cnemidophorus punctilinealis* Dickerson. *A*, U. S. N. M. No. 64460; *B*, A. M. N. H. No. 5539; *C*, A. M. N. H. No. 5533; *D*, (type), U. S. N. M. No. 64447. *A* and *B*, dorsal views; *C* and *D*, lateral views.

Cnemidophorus punctilinealis Dickerson

Cnemidophorus punctilinealis Dickerson, 1919, p. 475.[1]

Range.—Tiburon Island, Gulf of California; coastal strip of Sonora (?).

The specimens described under this name by Dickerson apparently represent a fairly distinct race of *C. melanostethus*, the dorsal coloration being more nearly that of *C. tessellatus tessellatus*, the ventral of *C. melanostethus*. This is exactly the coloration described by Van Denburgh and Slevin in specimens from Isla Partida, near Angel de la Guardia Island, as *C. dickersonæ;* a paratype of this species, in the collection of The American Museum of Natural History, is more nearly allied in color pattern to adult *C. disparilis*.

[1]Type: U. S. N. M. No. 64447. Paratypes: U. S. N. M. Nos. 64456–60, A. M. N. H. Nos. 5533–39.

Cnemidophorus maximus Cope

Cnemidophorus maximus Cope, 1863, p. 104; Stejneger and Barbour, 1917, p. 66.

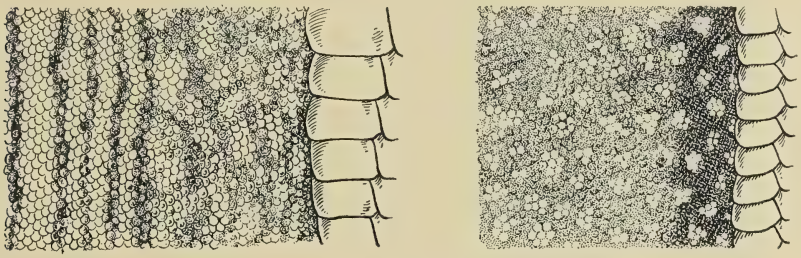
Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1863, p. 104; La Paz, Yarrow, 1882, p. 42; San José del Cabo, Miraflores, Sierra San Lazaro, Van Denburgh, 1895, p. 122; Espiritu Santo Island, Cope, 1900, p. 570; San Pedro, Triunfo, San Antonio, San Bartolo, Buena Vista, Agua Caliente, Todos Santos, Guamuchil Rancho (about 25 miles north of Cape St. Lucas), Van Denburgh and Slevin, 1921*a*, p. 62.

Six specimens of *Cnemidophorus maximus* were collected by the Albatross Expedition, two at Miraflores (A. M. N. H. Nos. 5542, 5570), and four in the San Bernardo Mts. (5549, 5551, 5656, U. S. N. M. No. 64461).

Two specimens in the Biological Survey collection come from Cape San Lucas (U. S. N. M. No. 37688) and Espiritu Santo Island (37691).

It is possible that the *C. grahami* and *C. sexlineatus* recorded by Mocquard (1899, p. 315) from Santa Rosalia and Mulege belong here.



A *B*

Fig. 13. *A*, Dorsal color pattern of type of *Cnemidophorus disparilis*, U. S. N. M. No. 64445, from the mid-dorsal line to the ventral plates. *B*, Similar view of dorsal pattern of *Cnemidophorus catalinensis*, A. M. N. H. No. 6885.

Cnemidophorus disparilis Dickerson

Cnemidophorus disparilis Dickerson, 1919, p. 473.[1]

Range.—Tiburon Island, Gulf of California.

This species was based on three specimens in the Albatross collection, one (the type) from Tiburon Island, and two juvenile specimens with no further data than "Lower California." The association of these two specimens with the type appears to be unjustifiable, as comparison of one of them with the types of *C. catalinensis* Van Denburgh and Slevin proves them to be indistinguishable (Van Denburgh, in correspondence).

[1]Type: U. S. N. M. No. 64445.

Conclusions on the development of the peculiar coloration of *disparilis* from the still more distinctive pattern of *C. martyris* and *C. catalinensis* are therefore baseless. An adequate understanding of the relations of the fifteen species of *Cnemidophorus* in the present list can only be reached by the comprehensive study of large series of each species, which are not at present available.

Cnemidophorus martyris Stejneger

Cnemidophorus martyris Stejneger, 1891, p. 407; Stejneger and Barbour, 1917, p. 66.

Range.—San Pedro Martir Island, Gulf of California.

Cnemidophorus catalinensis Van Denburgh and Slevin

Cnemidophorus catalinensis Van Denburgh and Slevin, 1921*c*, p. 396.

Range.—Santa Catalina Island, Gulf of California.

Two specimens (A. M. N. H. Nos. 6884–85), without other locality than "Lower California," referred to *C. disparilis* by Dickerson, almost certainly belong to this species, as has been noted above.

Cnemidophorus dickersonæ Van Denburgh and Slevin

Cnemidophorus dickersonæ Van Denburgh and Slevin, 1921*b*, p. 97.

Range.—Confined to Isla Partida, near Angel de la Guardia Island, Gulf of California.

Cnemidophorus canus Van Denburgh and Slevin

Cnemidophorus canus Van Denburgh and Slevin, 1921*b*, p. 97.

Range.—Sal Si Puedes Island, Gulf of California.

Cnemidophorus bacatus Van Denburgh and Slevin

Cnemidophorus bacatus Van Denburgh and Slevin, 1921*b*, p. 97.

Range.—San Pedro Nolasco Island, Gulf of California.

Key to the Species of *Cnemidophorus* in Lower California
(Exclusive of Insular Forms)

1. Postmental little if at all longer than the mental; parietals subequal in length to the fronto-parietals; size very large ..... *C. maximus.*
   Postmental longer than mental; parietals decidedly longer than the fronto-parietals; size moderate ..... 2.
2. Tail red distally; dorsal pattern of sharply defined black spots, in regular longitudinal and transverse rows ..... *C. rubidus.*
   Tail not red at end; dorsal pattern of longitudinal lines or rows of spots, not in regular transverse rows ..... 3.
3. Granular scales between collar and enlarged central gulars very small, abruptly differentiated from the latter ..... *C. bartolomas.*

Granular scales between collar and central gulars larger, passing more gradually into the latter.....4.

4. Central gulars strongly enlarged; throat heavily spotted with black, often united into transverse bands or reticulation.....*C. tessellatus stejnegeri.*

Central gulars little enlarged; throat often unspotted.....*C. t. tessellatus.*

Verticaria ceralbensis Van Denburgh and Slevin

Verticaria ceralbensis Van Denburgh and Slevin, 1921*c*, p. 396.

Range.—Ceralvo Island, Gulf of California.

Verticaria hyperythra hyperythra (Cope)

Cnemidophorus hyperythrus Cope, 1863, p. 103.

Verticaria hyperythra hyperythra Stejneger and Barbour, 1917, p. 65.

Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1863, p. 103; La Paz, Yarrow, 1882, p. 45; San José del Cabo, Miraflores, Van Denburgh, 1895, p. 128; Todos Santos, Agua Caliente, Buena Vista, San Bartolo, San Antonio, Triunfo, San Pedro, Guamuchil Ranch, and foothills of Sierre Laguna opposite Todos Santos, Van Denburgh and Slevin, 1921*a*, p. 63.

This species was collected by the Albatross Expedition at Cape San Lucas (U. S. N. M. No. 64483), Miraflores (A. M. N. H. Nos. 5565, 5670, 5672–75, U. S. N. M. No. 64481–2), and Pichlinque Bay (U. S. N. M. No. 64484). It agrees excellently with the definition of Van Denburgh (1895, p. 128) in the character of the supraoculars employed by him to distinguish it from *beldingi*. Eight specimens have the third supraocular only partly separated from the central head shields, two have it completely separated.

A specimen in the Biological Survey collection comes from Santa Anita (U. S. N. M. No. 37698).

Verticaria hyperythra beldingi Stejneger

Verticaria beldingi Stejneger, 1894, p. 17.

Verticaria hyperythra beldingi Stejneger and Barbour, 1917, p. 65.

Range.—Southwestern California, northeastern Lower California at least as far as Ensenada, Cedros Island, and Santa Margarita Island and Magdalena Islands.

Lower Californian Records.—Cedros Island, Stejneger, 1894, p. 17; Magdalena Island, Van Denburgh, 1895, p. 131; San Telmo, Ensenada, and between Salado and San Vicente, Van Denburgh, 1896, p. 1005.

The only *Verticaria* collected by the Albatross Expedition which I refer to this subspecies is a specimen from Santa Margarita Island (U. S. N. M. No. 64479). For a discussion of the relations of this form and *V. h. schmidti*, to which I refer the *Verticarias* of the remaining part of the peninsula north of the Cape area, see below.

Verticaria hyperythra schmidti Van Denburgh and Slevin

Verticaria sericea Meek, 1905, p. 14.

Verticaria hyperythra schmidti Van Denburgh and Slevin, 1921*c*, p. 397.

Range.—San Antonio (in northern Lower California) to Conception Bay and San Marcos Island.

Lower Californian Records.—Aguas Escondito, San Antonio, San Salado Cañon, and Rosarito, Meek, 1905, p. 14; San Marcos Island, Van Denburgh and Slevin, 1921*c*, p. 397.

Two specimens of *Verticaria* in the Albatross collection, from Castro Rancho, Concepcion Bay (U. S. N. M. No. 64252, and A. M. N. H. No. 5524) have a mid-dorsal light line, forked anteriorly, and four supra-oculars, and are accordingly identified with the form found on the island of San Marcos, to which my name is attached through the courtesy of Dr. Van Denburgh. A third specimen, from Mulege (A. M. N. H. No. 5523), has the typical coloration of *V. h. beldingi*, but I have included it with the present form on geographical grounds and on the evidence of specimens from northern Lower California.

Examination of the specimens from northern Lower California recorded by Meek as *V. sericea* shows that his reason for so recording them was their possession of the *sericea* color pattern; seven out of eleven specimens have a sharply defined median dorsal white line, dividing at the shoulders or a little farther back and sending the two branches to the parietals. Six of these specimens are from San Antonio, one from Aguas Escondito. The remaining four specimens from San Salado Cañon, Rosarito, Aguas Escondito and San Antonio exhibit various stages in the fusion of the two dorsal lines. In one, they are juxtaposed, but not actually united, on the posterior half of the body; in one, they are plainly fused on the posterior third of the back; in two, they unite at mid-body, but separate again for a short distance, reuniting at the base of the tail; three of these specimens show traces anteriorly of the fainter median dorsal line which is present in the normal pattern of both *hyperythra* and *beldingi*. Nine out of twelve specimens examined by me have the *sericea* type of color pattern. Van Denburgh's series of thirty-eight specimens of *V. h. beldingi* (1895, p. 131) did not exhibit this variation, and Van Denburgh and Slevin (1920, p. 64) in their recent paper, with twenty-four fresh specimens at hand from Ensenada, make no mention of it.

As far as I can discover, the specimens before me with the *sericea* color pattern or with a pattern intermediate between that of *sericea* and *hyperythra* are not structurally distinguishable from *V. h. beldingi;* and the color pattern itself is not firmly fixed, although it appears in the majority of the specimens before me. The specimens from Santa Rosalia

and San Ignacio recorded by Mocquard may be placed with this form on geographical grounds. His description indicates that they do not have the *sericea* pattern, and are therefore like our specimen from Mulege. My conception of *V. h. schmidti* therefore allows for the appearance of a minority of specimens colored like the form from which I believe it to be directly derived or in process of derivation.

Two localities represented by specimens in the Biological Survey collection from San Esteban (U. S. N. M. No. 37695) and San Francisquito (37697) are very satisfactory links between the records from the northern part of the peninsula and those from Mulege and San Marcos Island. In these two specimens the mid-dorsal pair of light lines is juxtaposed but not entirely confluent on the posterior two-thirds of the back.

Verticaria espiritensis Van Denburgh and Slevin

Verticaria espiritensis Van Denburgh and Slevin, 1921*c*, p. 397.

Range.—Espiritu Santo Island, Gulf of California.

Verticaria franciscensis Van Denburgh and Slevin

Verticaria franciscensis Van Denburgh and Slevin, 1921*c*, p. 397.

Range.—San Francisco Island, Gulf of California.

Verticaria sericea Van Denburgh

Verticaria sericea Van Denburgh, 1895, p. 132, Pl. xii ; Stejneger and Barbour, 1917, p. 65.

Range.—Confined to San José Island, Gulf of California.

A single specimen of this handsome and distinct species was taken by the Albatross Expedition on San José Island (U. S. N. M. No. 64480). It agrees excellently with the description of the type, the small scales of the border of the collar being quite unlike those of any form of *V. hyperythra*.

Verticaria cærulea Dickerson

Verticaria cærulea Dickerson, 1919, p. 472.[1]

Range.—Confined to Carmen Island, Gulf of California.

Five specimens forming the typical series of this species were collected by the Albatross Expedition on Carmen Island. They are directly related to *V. sericea* Van Denburgh from which they are slightly distinguishable in measurements. In the specimen of *V. sericea* at hand, the length of the hind leg forms .75 of the body length (.81 in the type). In the five *cæruleas*, the proportion ranges from .64 to .73, average .70.

[1]Type: U. S. N. M. No. 64251.

In addition to the generally light coloration mentioned in the original description, the absence of the two white lines on the posterior and superior aspect of the hind leg, which are very distinct in *sericea*, appears to be the most important distinctive character.

Verticaria picta Van Denburgh and Slevin

Verticaria picta Van Denburgh and Slevin, 1921*b*, p. 98.

Range.—Confined to Monserrate Island, Gulf of California.

The relations of this newly discovered form with those of the Lower Californian peninsula are unknown, the preliminary diagnosis only being at present available.

Key to the Peninsular Species of *Verticaria*

1. A single mid-dorsal line, forked anteriorly . . . . . *V. hyperythra schmidti.*
   A pair of sharply defined dorsal lines, sometimes with a faint line between them . 2.
2. Second supraocular usually in contact with the frontal . . . . *V. h. hyperythra.*
   Second supraocular usually separated from the frontal by a row of granules.
   V. h. beldingi.

Plestiodon skiltonianus Baird and Girard

Plestiodon skiltonianum Baird and Girard, 1852*b*, p. 349, Pl. iv, figs. 4–6.
Plestiodon skiltonianus Stejneger and Barbour, 1917, p. 71.

Range.—British Columbia to Lower California.

Lower Californian Records.—Cape St. Lucas, Yarrow, 1882, p. 41; San Francisquito, Sierra Laguna, Van Denburgh, 1895, p. 134; Los Coronados Islands, Van Denburgh, 1905, p. 18.

A specimen in the Biological Survey collection comes from Todos Santos Island, opposite Ensenada, (U. S. N. M. No. 37686).

The *P. lagunensis* described by Van Denburgh from the Sierra Laguna (*loc. cit.*) is not recognized by Stejneger and Barbour. It does not appear to me to warrant specific separation. Mr. Charles L. Camp informs me that the salmon-colored tail, one of the characters on which *lagunensis* was based, is common in *skiltonianus* in California.

Bipes biporus (Cope)

Euchirotes biporus Cope, 1894*a*, p. 436, figs. 5*a–e*.
Bipes biporus Stejneger and Barbour, 1917, p. 72.

Range.—Southern Lower California.

Lower Californian Records.—La Paz, Streets, 1877, p. 37.

Serpentes

Siagonodon humilis (Baird and Girard)

Rena humilis Baird and Girard, 1853, p. 143.
Siagonodon humilis Stejneger and Barbour, 1917, p. 73.

RANGE.—Southeastern California, southwestern Arizona, northwestern Mexico, and Lower California; southwestern Texas.[1]

LOWER CALIFORNIAN RECORDS.—Cape St. Lucas, Cope, 1861, p. 305; La Paz, Yarrow, 1882, p. 142; San Francisquito, Sierra Laguna, Van Denburgh, 1895, p. 136; San José del Cabo, Boulenger, 1896, p. 591; San Ignacio, Mocquard, 1899, p. 315; Cedros Island, Van Denburgh and Slevin, 1914, p. 145.

Two specimens of this species were secured at Cape San Lucas by the Albatross Expedition (A. M. N. H. No. 5576, U. S. N. M. No. 64580) Comparison with specimens from Tucson, Arizona, and Fort Clark, Texas, does not show any important differential character.

Lichanura roseofusca Cope

Lichanura roseofusca COPE, 1868, p. 2; STEJNEGER AND BARBOUR, 1917, p. 73.

RANGE.—Southern California and Arizona, northern Lower California.

LOWER CALIFORNIAN RECORDS.—Ensenada, Van Denburgh, 1896, p. 1005.

Lichanura trivirgata Cope

Lichanura trivirgata COPE, 1861, p. 304; STEJNEGER AND BARBOUR, 1917, p. 73.

RANGE.—Southern Lower California.

LOWER CALIFORNIAN RECORDS.—Cape St. Lucas, La Paz, Yarrow, 1882, p. 142.

U. S. N. M. No. 37525, ♂, Biological Survey collection, is from Santa Anita.

The scale counts of this specimen are as follows: Dorsals, 31–37–25; ventrals, 229; subcaudals, 47; scales about eye, 9; upper labials, 12; lower labials, 13; loreals, 3+4. The total length is 610 mm., the tail-length, 96 mm. The upper row of loreals contains two scales on one side, three on the other. The lower row has only one on each side.

Key to the Species of *Lichanura* in Lower California

Three dark longitudinal bands in strong contrast with the ground color; ventral plates 215–229 ..... *L. trivirgata.*

Bands, if present, not strongly contrasted with the ground color; ventral plates 224–241 ..... *L. roseofusca.*

Coluber flagellum piceus (Cope)

Bascanium piceum COPE, 1892, p. 625.

Coluber flagellum piceus STEJNEGER AND BARBOUR, 1917, p. 79.

RANGE.—Southwestern Arizona and Lower California.

LOWER CALIFORNIAN RECORDS.—La Paz, Yarrow, 1882, p. 112; Santa Margarita Id., Cope, 1895, p. 679; San José del Cabo, Miraflores, Van Denburgh, 1895, p. 148; Santa Rosalia, San Ignacio, Mocquard, 1899, p. 323; Joruncho Ranch, San Quentin, Rosarito, Parral, Meek, 1905, p. 15; San Pedro, Triunfo, San Bartolo, Agua Caliente, Todos Santos, Van Denburgh and Slevin, 1921*a*, p. 64.

[1] A specimen in The American Museum of Natural History (No. 8596) from Fort Clark, Kinney County, Texas, collected May 29, 1915, by Mr. Chapman Grant, U. S. Army, greatly extends the known range of this species.

The Albatross collection contains thirteen specimens of this form, the following localities being represented: Cape San Lucas (A. M. N. H. Nos. 5584, 6890); Miraflores (A. M. N. H. Nos. 5585, 5600–6503, U. S. N. M. Nos. 64591–5); and San Bartolome Bay (U. S. N. M. No. 64590).

The specimens range in size from 887 mm. to 1780 mm. The dorsal scale formula is regularly 19–17–13, but may be 19–17–12 by the loss of the median scale row posteriorly (U. S. N. M. Nos. 64590–91). There does not appear to be any sex difference in the number of ventral plates or subcaudals, nor in the proportionate length of the tail. In scale characters, this series does not change the range of variation shown in the tabulation of Van Denburgh (1921*a*, *loc. cit.*).

Specimens in the Biological Survey collection come from San Felipe Bay (U. S. N. M. No. 37549), Trinidad Valley (37551), Ojos Negros (37559), and San Ignacio (37552–3). Two of these (37559 and 37552) are of the dark color phase originally described as *piceus*. They correspond so closely in coloration to the specimen in the Albatross collection from San Bartolome Bay, and this in turn with Cope's description of *C. lateralis fuliginosus* from Santa Margarita Island, that I am convinced of their identity.

Two specimens, U. S. N. M. Nos. 37549 and 37559, show very distinct light lateral lines on the anterior third of the body, indicating, I believe, the relation of this form with *C. tæniatus*.

Coluber lateralis (Hallowell)

Leptophis lateralis Hallowell, 1853, p. 237.

Coluber lateralis Stejneger and Barbour, 1917, p. 80.

Range.—Southern and Lower California, absent from the Cape area.

Lower Californian Records.—Santa Rosalia, Mulege, San Ignacio, Mocquard, 1899, p. 324.

I refer Mocquard's records of *C. tæniatus* to this species, although it is entirely possible that they may prove to represent a distinct peninsular form or that they may be more nearly related to *C. barbouri* from Espiritu Santo Island.

Coluber aurigulus (Cope)

Drymobius aurigulus Cope, 1861, p. 301.

Coluber aurigulus Stejneger and Barbour, 1917, p. 78.

Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1861, p. 301; San José del Cabo, Van Denburgh, 1895, p. 149.

Coluber anthonyi (Stejneger)

Bascanion anthonyi Stejneger, 1901, p. 715.
Coluber anthonyi Stejneger and Barbour, 1917, p. 78.

Range.—Clarion Island, Revilla Gigedo Islands.

Coluber barbouri Van Denburgh and Slevin

Coluber borbouri Van Denburgh and Slevin, 1921*b*, p. 98.

Range.—Confined (as far as known) to Espiritu Santo Island, Gulf of California.

Key to the Species of *Coluber* in Lower California (Exclusive of Insular Forms)

1. No longitudinal light lines. Light brown above, with black nuchal bars (a melanistic phase occurs which is black or dark).....*C. flagellum piceus.*
   Longitudinal light lines on the sides.....2.
2. Lateral stripe continuous and uniform to base of tail.....*C. lateralis*
   Lateral stripe interrupted anteriorly, faint posteriorly.....*C. aurigulus.*

Salvadora hexalepis (Cope)

Phymothyra hexalepis Cope, 1866*a*, p. 304.
Salvadora hexalepis Stejneger and Barbour, 1917, p. 81.

Range.—Arizona, southern California and Lower California.

Lower Californian Records.—Cape St. Lucas, La Paz, Yarrow, 1882, p. 98; Comondu, Agua Caliente, San José del Cabo, Sierra San Lazaro, Van Denburgh, 1895, p. 147; San Pedro Martir Mt., Van Denburgh, 1896, p. 1005; Santa Anita, McLain, 1899, p. 3; Santa Rosalia, San Ignacio, Mocquard, 1899, p. 325; San Matias, Meek, 1905, p. 15; San Pedro, Buena Vista, Santiago, Miraflores, Todos Santos, Van Denburgh and Slevin, 1921*a*, p. 65.

A single specimen of this species (U. S. N. M. No. 64581, ♀), was collected by the Albatross Expedition at Miraflores. The total length is 678 mm.; tail, 162 mm.; ventral plates, 198; subcaudals, 89; dorsal scales, 19–17–13; a small inferior loreal on each side below the true loreal.

Two specimens in the Biological Survey collection are from 20 miles west of Santa Rosalia (U. S. N. M. No. 37517) and Todos Santos (37518).

Phyllorhynchus decurtatus (Cope)

Phimothyra decurtata Cope, 1868*a*, p. 310.
Phyllorhynchus decurtatus Stejneger and Barbour, 1917, p. 81.

Range.—Lower California, north to Riverside County, California and Yuma, Arizona.

Lower Californian Records.—Northern Lower California, Cope, 1868*a*, p. 310; La Paz, Stejneger, 1890, p. 155.

A study of the published records of the scale characters of this species reduces the distinctive characters of *P. browni* Stejneger, from Tucson,

to the keeling of the scales on the posterior part of the body in the latter species. Stejneger, in the original description (*loc. cit.*, p. 153) distinguished *P. browni* by the following characters:

	P. decurtatus	*P. browni*
Posterior Dorsal Scales	Smooth	Keeled
Ventral Plates	172–177	159
Subcaudals	26–27	31
Tail-Length	.08–.09	.13
Lateral Spots	Present	Absent
Dorsal Spots	29–32	15

The specimen recorded from La Paz by Van Denburgh and Slevin (1921*a*, p. 66) has 161 ventrals and 35 subcaudals, thus agreeing with the scale counts of *P. browni*. Mr. Tracy I. Storer of the Museum of Vertebrate Zoölogy of the University of California has kindly examined the specimen recorded from Palm Springs, Riverside Co., California, by Atsatt (1921, p. 38) and informs me that it has 187 ventral plates and 32 subcaudals.

A specimen (A. M. N. H. No. 20590) collected by Dr. F. E. Lutz and J. A. G. Rehn near Tucson agrees with *browni* in every scale character, but has the dorsal coloration of *decurtatus* while a second specimen from the same locality is a typical *browni*. This extraordinary dimorphism in coloration can only be explained by further studies, depending on the discovery of additional specimens. My suspicion that the differences in scale counts alluded to is a sex character is apparently groundless, as Dr. Stejneger reports U. S. N. M. No. 62561, a *browni*, as a female, and the specimen from Palm Springs is reported to be a male by Mr. Storer. I append a tabulation of the characters of the extant specimens of these two species so far as I can determine them.

Elaphe rosaliæ (Mocquard)

Coluber rosaliæ Mocquard, 1899, p. 321, Pl. xii, fig. 1.

Elaphe rosaliæ Stejneger and Barbour, 1917, p. 84.

Range.—Central and southern Lower California.

Lower Californian Records.—Santa Rosalia, Mocquard, 1899, p. 321; San Bartolo, Van Denburgh and Slevin, 1921*a*, p. 66.

Arizona elegans Kennicott

Arizona elegans Kennicott, 1859, p. 18, Pl. xiii; Stejneger and Barbour, 1917, p. 85.

Range.—Southwestern United States, northern Mexico, northern Lower California.

Lower Californian Records.—Ensenada, Van Denburgh and Slevin, 1921*a*, p. 67.

	Mus. No.	Sex	Locality	V. P.	Subc.	Tail: Total Length	No. of Dorsal Spots
Phyllorhynchus browni—Dorsal Scales Keeled	U. S. N. M.						
	15719 Type	?	Tucson	159	31	.13	15
	19258	♂	Tucson	156	30		
	62561	♀	Sabino Canyon, Arizona	158	32		
	A. M. N. H.						
	20590	♂	Tucson	159	33	.14	46
	A. N. S. P						
		♂	Tucson	160	33	.14	13
Phyllorhynchus decurtatus—Dorsal Scales Perfectly Smooth	A. N. S. P.						
	— Type		N. Lower Calif.	177	26	.08	32
	—		Yuma, Arizona	183	30	.10	47
	U. S. N. M.						
	12639	♀	La Paz	172	27	.09	29
	Cal. Acad. Sci.						
	45983		La Paz	161	35		
	Mus. V. Zoöl. Cal.						
		♂	Palm Springs, Calif.	187	32	.09	46

Two specimens in the Biological Survey collection come from San Tomas (U. S. N. M. No. 37519) and San Quintin (37529).

This species, while unquestionably present in the Colorado Desert area (Van Denburgh and Slevin, 1913, p. 417), appears to be more abundant in the San Diegan fauna, and also, perhaps locally, to the east of the desert.

Pituophis catenifer annectens Baird and Girard

Pituophis annectens Baird and Girard, 1853, p. 72.

Pituophis catenifer annectens Van Denburgh, 1920, p. 17.

Range.—Coast region of southern California and northern Lower California.

Lower Californian Records.—San Martin Island, Streets, 1877, p. 40; South Coronado Island, Van Denburgh and Slevin, 1914, p. 141; Ensenada, Van Denburgh, 1920, p. 17.

Pituophis catenifer rutilus Van Denburgh

Pituophis catenifer rutilus Van Denburgh, 1920, p. 24.

Range.—Southwestern Arizona, ranging into northern Lower California.

Lower Californian Records.—(?) Gardner's Laguna (Salton River), Cope, 1900, p. 879; (?) Trinidad, Meek, 1905, p. 15.

A single specimen (U. S. N. M. No. 37536) of *Pituophis* in the collection of the Biological Survey from Alamo appears to be referable to this form. The dorsal scale count is 29–31–23; the ventral plates number 239; the subcaudals, 50; the preoculars are two on each side; the dorsal dark spots are 32, the caudal, 8.

Van Denburgh (*loc. cit.*) has recorded this form from Yuma, and it is therefore not improbable from a geographic standpoint that it should occur in northern Lower California. Its presence on the Pacific slope in the San Diegan fauna, however, is an anomaly. It can only be explained by the assumption that it has entered Lower California via the deserts and spread northward from the southern end of the San Pedro Martir Mountains, (or via the San Felipe valley) very much as I suppose *Crotaphytus wislizenii* to have done.

There does not seem to be any possibility of regarding the present specimen as an aberrant *annectens*, as both scale and color characters separate it sharply from Van Denburgh's diagnosis of that form. Whether or not *P. c. deserticola* may occur in Lower California is uncertain, but I believe that the present form will be found to inhabit the northeastern part of the peninsula rather than *deserticola*, and I have therefore tentatively referred the records of Cope and Meek to *rutilus*.

Pituophis vertebralis (Blainville)

Coluber vertebralis Blainville, 1835, p. 293, Pl. xxvii, figs. 2–2*B*.
Pituophis vertebralis Stejneger and Barbour, 1917, p. 86.

Range.—Southern and central Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1860*a*, p. 342; La Paz, Yarrow, 1882, p. 107; San José del Cabo, Miraflores, Van Denburgh, 1895, p. 150; San Ignacio, Arroyo de Santa Agueda, Mocquard, 1899, p. 320; Ballenas Bay, Cope, 1900, p. 879; San Pedro, San Antonio, San Bartolo, Agua Caliente, Van Denburgh and Slevin, 1921*a*, p. 67.

Four specimens (A. M. N. H. Nos. 5588–90, U. S. N. M. No. 64583) collected at Miraflores are in the Albatross collection. The lengths range from 965 to 1665 mm.; the tail-length from 118 mm. to 220 mm. The tail-length/total length ranges from .13 to .15 in the three male specimens, .12 in the single female. In scale characters, these specimens fall within the range of variation of the four specimens recorded by Van Denburgh and Slevin (*loc. cit.*).

Specimens in the Biological Survey collection come from Santa Margarita Island (U. S. N. M. No. 37537), Cape San Lucas (37538), San José del Cabo (37539), and Santa Anita (37540).

Key to the Species of *Pituophis* in Lower California[1]

1. Coloration on anterior half of body largely red; upper labials usually 9 or 10; scales usually in 33 or 35 rows ..... *P. vertebralis.*
   Coloration anteriorly not reddish; upper labials usually 8; scale rows usually less than 35 ..... 2.
2. Dorsal blotches numerous, 54 to 89 on body, 14–29 on tail. *P. catenifer annectens.*
   Dorsal blotches fewer, 32–55 on body, 8–14 on tail ..... *P. c. rutilus.*

Diadophis amabilis Baird and Girard

Diadophis amabilis Baird and Girard, 1853, p. 113; Stejneger and Barbour, 1917, p. 75.

Range.—Oregon to Lower California, west of the desert divides in California.

The specimen in the Biological Survey collection, U. S. N. M. No. 37526, from San Matias Pass, in the San Pedro Martir Mountains, established this species in the fauna of Lower California.

The specimen measures 503 mm., tail-length, 86 mm. The dorsal scales are 15–15–14; the ventral plates, 203; the subcaudals, 60; preoculars, 2–2; postoculars, 2–2; temporals, 1–1, 1–1; upper labials, 7–8; lower labials, 8–8.

The ventral color includes the first lateral scale row; the small dark ventral spots are irregularly disposed, but are on the posterior margins of the ventral plates.

[1]After Van Denburgh, 1920, p. 12.

Lampropeltis getulus boylii (Baird and Girard)

Ophibolus boylii Baird and Girard, 1853, p. 82.

Lampropeltis getulus boylii Blanchard, 1920, p. 3.

Range.—Southwestern Utah to southern California and northern Lower California.

Lower Californian Records.—San Pedro Martir Mt., Van Denburgh, 1896, p. 1006; Beveridge Cañon, San Salado Cañon, San Quentin, Meek, 1905, p. 15; Ensenada, Blanchard, 1921, p. 87.

Lampropeltis getulus conjuncta Cope

Lampropeltis boylii var. *conjuncta* Cope, 1861, p. 301.

Lampropeltis getulus conjuncta Blanchard, 1920, p. 4.

Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1860, p. 255; La Paz, Yarrow, 1882, p. 92; San José del Cabo, Van Denburgh, 1895, p. 142; Santa Anita, Blanchard, 1921, p. 93.

Two specimens of this form were collected by the Albatross Expedition at Miraflores (A. M. N. H. No. 5649, U. S. N. M. No. 64584). The dorsal scales are 23–23–19 in one, 23–23–20 in the other; ventral plates 227 and 236; subcaudals 50 in both; specimens poorly preserved, measurements consequently not given. The coloration and head shields present no anomalies.

Lampropeltis getulus yumensis Blanchard

Lampropeltis getulus yumensis Blanchard, 1919, p. 6, Pl. 1, fig. 2; 1921, p. 66, fig. 28.

Range.—Southwestern Arizona, southeastern California, and adjacent areas in Lower California and Sonora.

Lower Californian Records.—Volcano Lake, Blanchard, 1919, p. 10 (list).

Lampropeltis californiæ californiæ (Blainville)

Coluber (Ophis) californiæ Blainville, 1835, p. 292, Pl. xxvii, figs. 1–1*B*.

Lampropeltis californiæ californiæ Blanchard, 1920, p. 3.

Range.—Fresno County, California, to northern Lower California.

Lower Californian Records.—San Ysidra Ranch, Cope, 1900, p. 922.

Lampropeltis californiæ nitida Van Denburgh

Lampropeltis nitida Van Denburgh, 1895, p. 143, Pl. xiv.

Lampropeltis californiæ nitida Blanchard, 1920, p. 3.

Range.—Southern Lower California.

Lower Californian Records.—San José del Cabo, Van Denburgh, 1895, p. 143.

I have referred a single specimen, taken at Miraflores, May 6, 1911 (U. S. N. M. No. 64585), to this species. The dorsal scales are 25–25–19; ventral plates, 226; subcaudals, 46; total length, 865 mm., tail, 106 mm.

In coloration, this specimen is even more closely allied to *L. californiæ californiæ* than the juvenile specimen described by Van Denburgh (*loc. cit.*, p. 144), thus fully justifying Blanchard's reference of *nitida* to subspecific rank.

The superior head shields are entirely dark; a yellow spot extends on the nasals, loreal and preocular; the fourth and fifth upper labials, and the temporals are spotted with yellow; a small spot just behind the parietals; an oblique band crosses the neck, from the fifth ventral to the tenth, about two scales wide dorsally, expanding to include five ventrals below, and extending at each end, about to the mid-ventral line; a half collar anterior to this band; two similar oblique bands follow these, beginning on the fifteenth and twenty-fifth ventrals respectively; behind this, there are no complete dorsal crossbands on the body, but there are six on the tail; twenty-two large yellow blotches on each side, beginning on the ends of the ventrals, one or two of which, however, may be entirely yellow, and extending dorsally to the fourth scale row; above these blotches is an obscure, much interrupted, yellow dorsolateral line on each side, on the seventh and eighth scale rows; the lateral blotches are connected by a lateral line at the edge of ventrals and on the first scale row on the posterior half of the body; an irregular, frequently indistinct vertebral line begins at a point opposite the thirty-fourth ventral, and continues with eight interruptions to the base of the tail; part of this line is straight, part wavy, and at several of the interruptions, the expanded end descends laterally and nearly joins a lateral blotch, indicating its derivation from a fundamentally ringed pattern.

The chief, if not the only, difference between this coloration and that of typical *californiæ* is the predominance of the dark color on the venter. On this ground, and for geographical reasons, the specimen is referred to *nitida*. It is not unlikely that larger collections will ultimately prove that *nitida* is a variety of the species *californiæ* rather than a vicarious geographical race.

Lampropeltis catalinensis Van Denburgh and Slevin

Lampropeltis catalinensis Van Denburgh and Slevin, 1921*c*, p. 397–398.

Range.—Santa Catalina Island, Gulf of California.

Key to the Species of *Lampropeltis* in Peninsular Lower California[1]

1. Dorsal longitudinal stripe, complete or interrupted.....2.
   Pattern of rings.....3.
2. Dorsal stripe white or yellow, sharply defined on a dark ground color.
   L. californiæ californiæ.

[1]After Blanchard, 1920, pp. 1–7.

Dorsal stripe less strongly contrasted with the ground color; belly uniform brown or with a few yellow blotches.....*L. californiæ nitida.*

3. White scales white to their bases, forming rings of uniform white; white bars on prefrontals broad, convex behind; lower labials usually 9. .*L. getulus boylii.*

White scales mostly brown at their bases; white bars on prefrontals broad or narrow; lower labials 9 or 10.....4.

4. White bars on prefrontals occupying less than half the area of these scutes; frontal plate uniform black, or with the white restricted to a narrow transverse bar at its anterior end; no white on parietals; lower labials usually 9. *L. getulus yumensis.*

White bars on prefrontals occupying more than half the area of these plates; frontal plate with prominent white markings; each parietal with one or more white spots; lower labials usually 10.....*L. getulus conjuncta.*

Rhinocheilus lecontei Baird and Girard

Rhinocheilus lecontei Baird and Girard, 1853, p. 120; Stejneger and Barbour, 1917, p. 91.

Range.—Idaho to Lower California, east to Texas.

Lower Californian Records.—"At or to the south of Magdalena Bay," Lockington, 1880, p. 295.

A specimen in the Biological Survey collection, U. S. N. M. No. 37516, is from Ensenada.

The scale characters of this specimen, a male, are as follows: Dorsal scales, 23–23–19; ventral plates, 208; subcaudals, 49; preoculars, 1–1; postoculars, 2–2; temporals, 2–4, 2–3, upper labials, 7–8; lower labials, 9–9. The total length is 625 mm., the tail-length, 83 mm.

Hypsiglena ochrorhynchus ochrorhynchus Cope

Hypsiglena ochrorhynchus Cope, 1860, p. 246.

Hypsiglena ochrorhynchus ochrorhynchus Stejneger and Barbour, 1917, p. 93.

Range.—Lower California, southern California, and adjacent parts of Arizona and Sonora.

Lower Californian Records.—Cape St. Lucas, Cope, 1860, p. 246; Magdalena Bay (or south), Lockington, 1880, p. 295; San José del Cabo, Sierra San Lazaro, San Francisquito (Sierra Laguna), Van Denburgh, 1895, p. 144; Mulege, Mocquard, 1899, p. 325; Los Coronados Islands, Van Denburgh and Slevin, 1914, p. 141; Sierra Laguna, Van Denburgh and Slevin, 1921*a*, p. 68.

Two specimens in the Biological Survey collection come from Cape San Lucas (U. S. N. M. No. 37528) and Santa Anita (37527).

The scale characters and measurements of these specimens are as follows:

Number	37527, ♂	37528, ♂
Dorsal Scales	21–21–15	21–21–17
Ventral Plates	172	168
Subcaudals	51	(tail broken)
Total Length	347 mm.	
Tail-length	63 mm.	

They agree with the specimen described by Van Denburgh and Slevin (1921*a*, p. 68) in the disposition of the head shields, with the exception that there are two preoculars, a small inferior and a large superior, in each.

Natrix valida (Kennicott)

Regina valida Kennicott, 1860, p. 334.
Natrix valida Stejneger and Barbour, 1917, p. 97.

Range.—Western Mexico, Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1860*a*, p. 341; La Paz, Yarrow, 1882, p. 132; San José del Cabo, Miraflores, Van Denburgh, 1895, p. 154; Mount San Rafael (near Agua Caliente), Santiago, Van Denburgh and Slevin, 1921*a*, p. 68.

The six specimens in the Albatross collection from San José del Cabo (A. M. N. H. Nos. 5573, 5581, 5583, U. S. N. M. No. 64582) and Miraflores (A. M. N. H. Nos. 5604–5) present no variation not already known in this species.

One specimen in the Biological Survey collection comes from San José del Cabo (U. S. N. M. No. 37545).

Thamnophis ordinoides vagrans (Baird and Girard)

Eutænia vagrans Baird and Girard, 1853, p. 35.
Thamnophis ordinoides vagrans Van Denburgh and Slevin, 1918, p. 240.

Range.—Eastern Washington and Oregon, Idaho, south to northern Arizona and eastern California, reappearing in the San Pedro Martir Mountains, Lower California.

Lower Californian Records.—San Pedro Martir Mountain, Van Denburgh, 1896, p. 1007.

Thamnophis ordinoides hammondii (Kennicott)

Eutænia hammondii Kennicott, 1860, p. 322.
Thamnophis ordinoides hammondii Van Denburgh and Slevin, 1918, p. 256.

Range.—Southwestern Lower California and northwestern Lower California.

Lower Californian Records.—Comondu, Van Denburgh, 1896, p. 1008; Mulege, San Ignacio, Mocquard, 1899, p. 327; San Antonio, La Grulla, Ruthven, 1908, p. 133.

Four specimens in the Biological Survey collection come from Hanson Laguna (U. S. N. M. Nos. 37542–4) and Ensenada (37541).

Thamnophis megalops (Kennicott)

Eutænia megalops Kennicott, 1860, p. 33.
Thamnophis megalops Stejneger and Barbour, 1917, p. 101.

Range.—The Mexican Plateau region, north to southern Arizona and New Mexico, west to Yuma, Arizona, and the Cocopah Mountains, Lower California.

A specimen in the Biological Survey collection, U. S. N. M. No. 37514, from the Cocopah Mountains, east base, is the first record of this form from Lower California.

The lateral light line is plainly on the third and fourth scale rows anteriorly. The dorsal scale formula is 23–21–19–17; ventral plates, 152; subcaudals, 41 +; preoculars, 1–1; upper labials, 8–8; lower labials, 10–10.

The occurrence of this form in northern Lower California is not surprising in view of its occurrence at Yuma.

Key to the Species of *Thamnophis* in Lower California

1. Dorsal light line present ..... 2.
   No dorsal light line ..... *T. ordinoides hammondii.*
2. Lateral light line anteriorly on the third and fourth scale rows .... *T. megalops.*
   Lateral light line anteriorly on the second and third scale rows.
   T. ordinoides vagrans.

Sonora episcopa (Kennicott)

Lamprosoma episcopum Kennicott, 1859, p. 22, Pl. viii, fig. 2.

Sonora episcopa Stejneger and Barbour, 1917, p. 92.

Range.—Texas to southeastern California, south into Mexico.

Lower Californian Records.—Cape St. Lucas, Baird, 1859, p. 299; Santa Rosalia, Mocquard, 1899, p. 319.

Chilomeniscus stramineus Cope

Chilomeniscus stramineus Cope, 1860*a*, p. 339; Stejneger and Barbour, 1917, p. 94.

Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1860*a*, p. 339; La Paz, Yarrow, 1882, p. 86; San José del Cabo, Miraflores, Van Denburgh, 1895, p. 138; San Marthe, Cope, 1900, p. 950.

Four specimens in the present collection, one from Cape San Lucas (A. M. N. H. No. 5578), three from Miraflores (A. M. N. H. Nos. 5574–5, U. S. N. M. No. 64579).

These specimens show very little variation; the dorsal scales are uniformly in thirteen rows; ventral plates (in the order named) 109, 117, 113, 121; subcaudals 24, 25, 28, 25; rostral in every case separated from the prefrontals and the nasals from the preoculars. The largest specimen (5578) measures 230 mm., tail, 32 mm.

Chilomeniscus ephippicus Cope

Chilomeniscus ephippicus Cope, 1867*a*, p. 85; Stejneger and Barbour, 1917, p. 93.

Range.—Southern Lower California to the Colorado Desert, reaching Tucson, Arizona, to the east.

Lower Californian Records.—La Paz, Yarrow, 1882, p. 86; Santa Rosalia and Mulege, Mocquard, 1899, p. 317; San Fernando, Cope, 1900, p. 951; Todos Santos, Van Denburgh and Slevin, 1921*a*, p. 70.

The record of Van Denburgh and Slevin (*loc. cit.*) is only tentatively referred to this form, as they do not describe its coloration.

Chilomeniscus punctatissimus Van Denburgh and Slevin

Chilomeniscus punctatissimus Van Denburgh and Slevin, 1921*b*, p. 98.

Range.—Espiritu Santo Island, Gulf of California, and Magdalena Island.

A specimen in the Biological Survey collection, U. S. N. M. No. 37521, from Magdalena Island, appears to be very closely allied to this newly described form from the opposite side of the peninsula. It differs from the type in having the scales of the light bands immaculate, instead of spotted. The large number of crossbands, which is the same in both specimens, seems to me a more important character than the spotting.

The specimen from Magdalena Island has the rostral broad and in contact with the prefrontals posteriorly; nasals expanded on the upper side of the snout, probably by fusion with the frontonasals; prefrontals reaching the labials on each side; frontal broad, six-sided; supraoculars small; a minute preocular on each side; two postoculars; temporals, 1–1 on each side; upper labials, 7, third and fourth entering the eye; lower labials, 9, the first five in contact with the anterior chin shields; dorsal scales, 15–13–13; ventral plates, 127; subcaudals, 25.

Top of the head very dark brown, lighter on the snout, the lower border of the labials light; back crossed by 32 bands of dark brown about equal to the light interspaces and reaching the first row of scales on each side; 7 bands on the tail.

The total length is 98 mm.; tail, 11 mm.

Chilomeniscus cinctus Cope

Chilomeniscus cinctus Cope, 1861, p. 303.

Range.—The Colorado Desert, to middle Lower California on the west and Sonora on the east.

Lower Californian Records.—Ballenas Bay, Cope, 1900, p. 952.

A specimen in the Biological Survey collection, U. S. N. M. No. 37520, from San Quintin, is characterized by a pattern of dark rings, completely encircling the body.

Dorsal scale rows, 15–13–13, ventral plates, 120; subcaudals, 25; the prefrontals meet the labials laterally; upper labials, 7–7; lower labials, 9–9; preoculars, 1–1; postoculars, 2–2; rostral broadly in contact with the prefrontals.

There are twenty-two dark brown rings encircling the body, with four more on the tail and a nuchal bar which does not reach the ventrals. The dark rings are wider than the interspaces dorsally, narrower ventrally, where they occupy quite regularly two ventral plates.

The forms of the genus *Chilomeniscus* are in considerable confusion and by no means well understood. Without sufficient material at hand to clear up the points in question, I prefer to lean to the side of the excessive analysis rather than synthesis. Van Denburgh and Slevin (1913, p. 410) reduce the genus to two species, *stramineus* from the Cape area of Lower California, and *cinctus* ranging from southern Lower California, southeastern California, western Arizona, and Sonora. This view is maintained by them in their recent list of Lower Californian forms (1921*a*, p. 52), with the subsequent addition of a new form, *C. punctatissimus* from Espiritu Santo Island.

Cope's analysis of the genus (1900, p. 948), unfortunately somewhat confused in compilation, recognizes, in addition to the well-defined *stramineus*, three crossbanded forms, *C. ephippicus*, *C. fasciatus*, and *C cinctus*. Of these *ephippicus* and *fasciatus* have the venter immaculate, with crossbands confined to the back, while *cinctus* is sharply set off by having the body completely encircled by black bands. This may well prove to be a variable character, not of specific value, but I know of no evidence at present of intergradation or variation in this character. The scale character employed by Cope to separate *fasciatus* and *ephippicus*, however, has been shown by Van Denburgh and Slevin (1913, *loc. cit.*) to be invalid, and I follow them in uniting these two forms, but not in uniting *ephippicus* with *cinctus*. Van Denburgh and Slevin make no mention of the coloration. The evidence presented by Mocquard for the union of *fasciatus* and *cinctus* (1899, p. 318) does not seem to be sufficient for a final decision on this point.

Reference to the following key will make clear the characters which distinguish the forms recognized in the present analysis. It is notable that *C. cinctus* and *C. ephippicus* have broadly overlapping ranges, *C. ephippicus* occurring alone in southern Lower California, *C. cinctus* alone in Sonora, while northern Lower California and the Colorado Desert area have both forms.

Key to the Species of *Chilomeniscus*

1. Rostral not in contact with the prefrontals; no dark crossbands, each scale with a dark spot ..... *C. stramineus.*
   Rostral in contact with the prefrontals; dark crossbands or rings on the body . 2.
2. Body completely encircled by dark rings ..... *C. cinctus.*
   Dark crossbands on the back, venter immaculate ..... 3.
3. Crossbands about 25 ..... *C. ephippicus.*
   Crossbands about 39, with or without dark spots on the scales of the light rings. *C. punctatissimus.*

Tantilla planiceps (Blainville)

Coluber planiceps Blainville, 1835, p. 294, Pl. xxvii, figs. 3–3*B*.
Tantilla planiceps Stejneger and Barbour, 1917, p. 105.

Range.—Southern Lower California.

Lower Californian Records.—San José del Cabo, Sierra Laguna, Van Denburgh, 1895, p. 140; Santa Rosalia, San Ignacio, Mocquard, 1899, p. 316.

Trimorphodon lyrophanes (Cope)

Lycodon lyrophanes Cope, 1860*a*, p. 343.
Trimorphodon lyrophanes Stejneger and Barbour, 1917, p. 104.

Range.—Southern Arizona and Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1860*a*, p. 343; La Paz, Yarrow, 1882, p. 98; San Josè del Cabo, Sierra San Lazaro, Van Denburgh, 1895, p. 155; Santa Rosalia, Mocquard, 1899, p. 330.

A single specimen, (U. S. N. M. No. 64578), from Miraflores, is in the Albatross collection. Its stomach contains a juvenile specimen of *Ctenosaura hemilopha*.

The dorsal scales are 25–21–15; ventral plates, 241; subcaudals, 58+. The total length is somewhat more than 800 mm. (tail slightly mutilated). The loreal is double on one side, single on the other.

There are three specimens in the collection made by the Biological Survey, one from La Paz (U. S. N. M. No. 37522), and two from Santa Anita (37523–4).

Micrurus euryxanthus (Kennicott)

Elaps euryxanthus Kennicott, 1860, p. 337.
Micrurus euryxanthus Stejneger and Barbour, 1917, p. 106.

Range.—Southern New Mexico and Arizona, northern Mexico.

Recorded from Tiburon Island by Streets, 1877, p. 40.

Crotalus molossus Baird and Girard

Crotalus molossus Baird and Girard, 1853, p. 10; Stejneger and Barbour, 1917, p. 110.

Range.—Southern Texas to Arizona and northern Mexico; San Esteban Island.

This species does not enter peninsular Lower California. A specimen secured on San Esteban Island in the Gulf of California by the Albatross Expedition (U. S. N. M. No. 64586) is referable to this species in all scale characters, but is exceptionally pale in color, neither the outlines of the rhombs nor the two spots normally enclosed in the rhombs being distinctly marked. This is due chiefly to the paleness of the general coloration.

The ventral plates number 189, the subcaudals 26, and the dorsal scale formula is 31–27–21. The total length is 476 mm., the tail (exclusive of a single rattle) 36 mm.

The presence of this species on San Esteban is further indication of the Sonoran, not Lower Californian, character of its fauna; and this conclusion is quite independent of the possibility that further adult specimens from San Esteban might justify the description of an insular race.

Crotalus tortugensis Van Denburgh and Slevin

Crotalus tortugensis Van Denburgh and Slevin, 1921*c*, p. 398

Range.—Tortuga Island, Gulf of California.

Crotalus oreganus Holbrook

Crotalus oreganus Holbrook, 1840, p. 115, Pl. xxix.

Crotalus oregonus Stejneger and Barbour, 1917, p. 110.

Range.—British Columbia to northwestern Lower California.

Lower Californian Records.—Los Coronados Islands, Streets, 1877, p. 40; "75 miles S. E. of San Diego," Lockington, 1880, p. 295; San Pedro Martir Mt., Van Denburgh, 1896, p. 1007; San José, Meek, 1905, p. 17.

A specimen in the Biological Survey collection, U. S. N. M. No. 37575, is from La Grulla.

Crotalus atrox atrox Baird and Girard

Crotalus atrox Baird and Girard, 1853, p. 5; Stejneger and Barbour, 1917, p. 108.

Range.—Texas and northern Mexico to southeastern California, entering northeastern Lower California.

Lower Californian Records.—East side of Cocopah Mountains, Murphy, 1917, p. 57.

I have no hesitation in recording this species from Lower California on the basis of the verbal record above quoted, as there is no snake in this area with which *Crotalus atrox* could readily be confused.

Crotalus atrox lucasensis Van Denburgh

Crotalus lucasensis Van Denburgh, 1920*a*, p. 29, Pl. iii.

Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1861, p. 292; La Paz, Yarrow, 1882, p. 75. San José del Cabo, Sierra El Taste, Van Denburgh, 1895, p. 156; Santa Rosalia, San Ignacio, Mulege, Mocquard, 1899, p. 332.

Six specimens of this species were collected by the Albatross Expedition at Miraflores (A. M. N. H. Nos. 5596–97, 5644–45, U. S. N. M. No. 64589) and head of Concepcion Bay (A. M. N. H. No. 6883). They agree with Van Denburgh's description in having the dorsal rhombs distinctly outlined laterally.

The dorsal scales range from 35–27–23 to 31–25–21. The ventrals range from 182 to 188 in four males, 189 and 195 in the two females; subcaudals 25 to 29 in males, 21 in both females. There are three black

caudal rings in the females, five to seven in the males. The tail is relatively much shorter in the female specimens, .05 of the total length, .07 to .08 in the males. The largest specimen (A. M. N. H. No. 5645, ♂) measures 1015 mm., tail 88 mm.

As *Crotalus atrox* certainly enters the peninsula of Lower California at the north, and as the differences on which *lucasensis* is based are slight, the use of a trinomial seems warranted.

Three specimens in the Biological Survey collection from Cape San Lucas (U. S. N. M. No. 37567), La Laguna (37568), and Santa Anita (37569).

Crotalus atrox elegans, new subspecies

Diagnsotic Characters.—Characters of *Crotalus atrox*, from which it is distinguished by the higher number of ventral plates and the reddish brown color; distinguished from *C. atrox lucasensis* by the incompleteness laterally of the light outlines of the dorsal rhombs, and by the higher number of ventral plates.

Range.—Angel de la Guardia Island, Gulf of California.

Type.—U. S. N. M. No. 64452; ♂; Angel de la Guardia Island, Gulf of California; April 10, 1911; Albatross Expedition.

Description of Type.—Head subtriangular, covered with numerous small scales; ten scales in a line, between the large supraoculars; rostral higher than wide; two large preoculars on each side, of which the lower enters the loreal pit; two superior loreals on each side; four or five scales from the eye to the upper labials; upper labials 16–17, lower labials 18, of which only three on each side are in contact with the chin shields; dorsal scales, 35–27–21; ventrals, 197; subcaudals, 26; total length, 920 mm.; tail, 60 mm.

General color light reddish brown, marked dorsally with a series of slightly darker rhombs, which are bordered by narrow light lines; rhombs lighter at the center; these rhombic markings become difficult to distinguish on the anterior fourth of the body, but the light scales of their borders can be distinguished on the vertebral line; on the posterior fourth of the body, the light lines become entirely faded, the slightly darker markings forming broad transverse bands. Tail yellow, with five black rings, incomplete ventrally; venter uniform pale yellow; an indistinct light line from the preoculars to the middle of the labial border, and a very faint line from the posterior corner of the eye to the sixteenth upper labial.

Notes on Paratypes.—The two female specimens from Angel de la Guardia (A. M. N. H. Nos. 5231 and 5586) have respectively 200 and 199 ventrals, and 21 and 20 subcaudals. The dorsal scale count is 31–27–21. The ground color is more grayish but shows a trace of the reddish tinge which is better marked in the type. The dorsal light lines enclosing the rhombs are incomplete at the sides.

I have described this form as a subspecies of *C. atrox* in order to indicate its obvious relations. The higher ventral scale count is nearly reached in a specimen of *C. atrox lucasensis* which has 195 ventrals; the average for the two forms is evidently quite different, but the extremes probably overlap. Additional material is required to determine whether it is to be considered an off-shoot of *lucasensis* or of *atrox atrox*.

Crotalus exsul Garman

Crotalus exsul Garman, 1883, p. 114; Stejneger and Barbour, 1917, p. 109.

Range.—Southwestern California and northeastern Lower California to Cedros Island.

Lower Californian Records.—Cedros Island, Garman, 1883, p. 114; Ensenada, Van Denburgh, 1896, p. 1007; San Salado Cañon, San Matias, Santa Cataline, Agua Escondito, Matcmi, San Quentin, Meek, 1905, p. 17; "Turtle Bay," Van Denburgh and Slevin, 1921*a*, p. 71.

The Albatross collection contains a single very large specimen (U. S. N. M. No. 64588) of this species, without definite locality, but almost certainly from Cedros Island.

Three specimens in the collection of the Biological Survey are from San Quintin (U. S. N. M. Nos. 37571–2) and San Tomas (37574).

The characters employed by Cope in his key to the species of *Crotalus* (1900, p. 1152) to distinguish *Crotalus ruber* (=*exsul*) are somewhat misleading, especially as he separates *ruber* widely from *atrox* which I believe to be its nearest relative. There is a tendency to widening of the rostral, and to obscurity of the canthus rostralis in *exsul*, but neither character is constant, and the reddish coloration must be relied on in most cases as a key character.

Crotalus enyo (Cope)

Caudisona enyo Cope, 1861, p. 293.

Crotalus enyo Stejneger and Barbour, 1917, p. 109.

Range.—Southern Lower California.

Lower Californian Records.—Cape St. Lucas, La Paz, Yarrow, 1882, p. 74; San José del Cabo, Van Denburgh 1895, p. 157; Mulege, Mocquard, 1899, p. 333; Miraflores, San Antonio, Todos Santos, San Bartolo, San Pedro, Sierra Laguna, Van Denburgh and Slevin, 1921*a*, p. 71.

A specimen collected by the Biological Survey, U. S. N. M. No. 37570, is from Santa Anita.

Crotalus cerastes Hallowell

Crotalus cerastes Hallowell, 1854, p. 95; Stejneger and Barbour, 1917, p. 108.

Range.—Southwestern Utah to southeastern California and northeastern Lower California.

Lower Californian Records.—San Felipe, Meek, 1905, p. 18.

Four specimens in the collection of the Biological Survey are from San Felipe Bay (U. S. N. M. Nos. 37562–3), Cocopah Mountains, east base (37564), and San Francisquito (37565).

Crotalus mitchellii (Cope)

Caudisona mitchellii Cope, 1861, p. 293.

Crotalus mitchellii Stejneger and Barbour, 1917, p. 110.

Range.—Southwestern Arizona to southern Lower California.

Lower Californian Records.—Cape St. Lucas, Cope, 1861, p. 293; Angel de la Guardia Island, Streets, 1877, p. 39; La Paz, Yarrow, 1882, p. 73; Santa Margarita Island, Las Huevitas, Sierra El Taste, San José del Cabo, Van Denburgh, 1894*a*, p. 450; Santa Rosalia, Mulege, San Ignacio, Mocquard, 1899, p. 331; Parral, San Matias, Meek, 1905, p. 18; Agua Caliente, Van Denburgh and Slevin, 1921*a*, p. 72.

Two specimens (A. M. N. H. No. 5646 and U. S. N. M. No. 64587) of this species were collected by the Albatross Expedition at Miraflores.

One typical pale specimen, U. S. N. M. No. 37566, comes from the Cocopah Mountains, east base, collected by the Biological Survey Expedition.

Crotalus goldmani,[1] new species

Diagnostic Characters.—Allied to *Crotalus mitchellii* by the separation of the rostral and nasal plates by a row of scales; distinguished by: (1) dark reddish brown coloration, with the dark markings more nearly rhombic, and with light centers; (2) scales narrower and more convex; (3) supraocular plate broken up into three or four small scales.

Range.—Known only from the type locality.

Type.—U. S. N. M. No. 37573, ♂; El Piñon, Lower California, 5300 feet; July 9, 1905; E. W. Nelson and A. E. Goldman.

Description of Type.—Habitus apparently stout, tail short, muzzle short; scales of top of head small, somewhat convex; canthus rostralis obtuse; rostral slightly higher than wide; a single row of scales between rostral and nasal; two preoculars, with two loreals between them and the posterior nasal, on each side; upper labials, 18–19; lower labials, 16–17; a small triangular area of small scales (8 or 9) between the loreal pit, the nasals, and the labials; supraocular divided into four scales on one side, three on the other, but with the fourth indicated; scales rather convex, especially on the head and tail, only the first row smooth; ventral plates, 180; subcaudals, 25; dorsal scales, 23–27–21.

Total length, 850 mm.; tail-length to base of rattle, 70 mm.

General color brownish; ventrals with irregular brown punctation; back with rhombic markings of darker brown, as long as wide; on the anterior part of the body they are notched on the mid-line; posteriorly they become wider and narrower, with seven dark bands on the top of the tail, the last three nearly black.

In view of the known variability in the scutellation of *C. mitchellii*, the present specimen may prove to be merely an abnormal one of that species. *C. mitchellii*, however, has not previously been recorded from the Pacific slope of the San Pedro Martir Mountains. It is typically a desert species, although it ranges into the lower border of the upper Sonoran life zone in California (4500 feet, at Asbestos Spring, east slope of the San Jacinto Mountains). The conditions described at El Piñon by Nelson (1921, p. 20) indicate thoroughly non-arid habitat conditions.

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[1]Named for Mr. A. E. Goldman, Bureau of Biological Survey, associated with Dr. E. W. Nelson in the Lower Californian explorations of the Bureau of Biological Survey.

The true status of *C. goldmani*, therefore, remains to be cleared up, and in naming it, I hope to have emphasized the fact that it presents a problem for investigation.

Key to the Species of *Crotalus* in Lower California and Adjacent Islands

1. Superciliary scales produced into a horn-like process.....*C. cerastes.*
   Superciliary scales flat.....2.
2. Nasal plate separated from the rostral by one or two rows of small scales....3.
   Nasal in contact with the rostral.....4.
3. Supraocular a single shield.....*C. mitchellii.*
   Supraocular broken up into several plates.....*C. goldmani.*
4. Top of head anteriorly with three pairs of enlarged scales in contact..*C. molossus.*
   Top of head anteriorly with small scales.....5.
5. Rostral wider than high.....*C. enyo.*
   Rostral higher than wide (rarely nearly as wide as high).....6.
6. Canthus rostralis often ill-defined; coloration reddish, markings indistinct in adult; pattern of side of head as in *C. atrox*.....*C. exsul.*
   Canthus rostralis distinct, dorsal rhombs distinct.....7.
7. Tail light with three to six black rings; light postsuperciliary line reaches the scale row next to the labials anterior to the angle of the mouth. (*C. atrox*).8.
   Tail with more numerous crossbands, less sharply defined; postsuperciliary line passes behind angle of mouth.....*C. oreganus.*
8. Dorsal rhombs with a light spot on each side (as in *C. molossus*), sometimes confluent.....*C. tortugensis.*
   Dorsal rhombs not as above.....9.
9. Ventral plates 197–200.....*C. atrox elegans.*
   Ventral plates fewer, maximum 195.....10.
10. Dorsal rhombs sharply defined; light borders well defined laterally. *C. atrox lucasensis.*
    Dorsal rhombs less distinct, especially at the sides, the coloration without strong contrast.....*C. atrox atrox.*

Crotalus tortugensis is not sufficiently characterized to make its place in the above key certain; I have tentatively placed it as an ally to *C. atrox.*

TESTUDINATA

Pseudemys ornata nebulosa (Van Denburgh)

Chrysemys nebulosa VAN DENBURGH, 1895, p. 84, Pls. IV–VI.

Pseudemys ornata nebulosa STEJNEGER AND BARBOUR, 1917, p. 120.

RANGE.—Southern Lower California.

LOWER CALIFORNIAN RECORDS.—Los Dolores, Agua Caliente, San José del Cabo, Van Denburgh, 1895, p. 85.

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PLATES XLVII TO LVII

Plate XLVII

Valley of the San José River looking westward, the town of San José del Cabo visible at the foot of the distant hills. The luxuriant vegetation of the irrigated fields of the river bottom (at left) contrasts with the sparse growth, among which cacti may be distinguished, on the rise of ground (at right). Most of the species of reptiles characteristic of the Cape fauna may be found here.

Plate XLVIII

Agua Verde Bay. The abrupt eastern escarpment of the mountains, with a narrow stretch of coastal plain is characteristic of the topography of the gulf coast of Lower California. *Callisaurus ventralis gabbii* and *Verticaria hyperythra schmidti* are among the reptiles characteristic of this locality, and of this side of the peninsula.

PLATE XLIX

Sauromalus varius Dickerson. A. M. N. H. No. 5618, San Esteban Island, × ½ (total length 458 mm.).

PLATE L

Fig. 1. *Sauromalus hispidus* Stejneger. A. M. N. H. No. 5608, Angel de la Guardia Island. To show spinous character of nuchal scales in the adult.

Fig. 2. *Sauromalus hispidus* Stejneger, U. S. N. M. No. 64572, same locality. To show transverse dorsal bands of the juvenile coloration. (Neck constricted by label.)

Fig. 3. *Sauromalus ater* Duméril. A. M. N. H. No. 6808, La Paz. To show the similarity of the juvenile coloration and the difference in nuchal scales in a specimen of approximately the same size as *S. hispidus* in Fig. 2.

1

2 3

Plate LI

Fig. 1. Ventral coloration in males of the several species of *Callisaurus*. From left to right, *C. ventralis ventralis* Hallowell, A. M. N. H. No. 2451; *C. ventralis inusitatus* Dickerson, A. M. N. H. No. 5334; *C. splendidus* Dickerson, A. M. N. H. No. 5372; *C. ventralis gabbii* Cope, A. M. N. H. No. 5308; *C. draconoides* Blainville, U. S. N. M. No. 64514; and *C. crinitus* Cope, A. M. N. H. No. 5502. The coloration of *C. ventralis myurus* (not figured) is indistinguishable from that of *C. ventralis ventralis*.

Fig. 2. *Callisaurus draconoides* Blainville, normal dorsal coloration; A. M. N. H. No. 5659 (left) and U. S. N. M No. 64518 (right).

Fig. 3. Same species, light color phase; A. M. N. H. No. 5391 (left) and U. S. N. M. No. 64514 (right).

1

2

3

Plate LII

Fig. 1. *Callisaurus crinitus* Cope, U. S. N. M. No. 64530. To show the characteristic, finely maculate dorsal coloration.

Fig. 2. *Callisaurus ventralis inusitatus* Dickerson, A. M. N. H. No. 5317. To show extreme elongation of body and limbs, and dorsal color pattern.

Fig. 3. Enlarged view of the lateral digital scales of the fourth toe of *Callisaurus crinitus* which form the "fringe."

3

1 2

Plate LIII

Fig. 1. *Uma notata* Baird, A. M. N. H. Nos. 22240 (right) and 22241 (left). To show dorsal color pattern and stout, short-legged habitus.

Fig. 2. Enlarged view of the base of the fourth toe of *Uma notata*, Field Mus. No. 1203, to show scales of the digital fringe

1 2

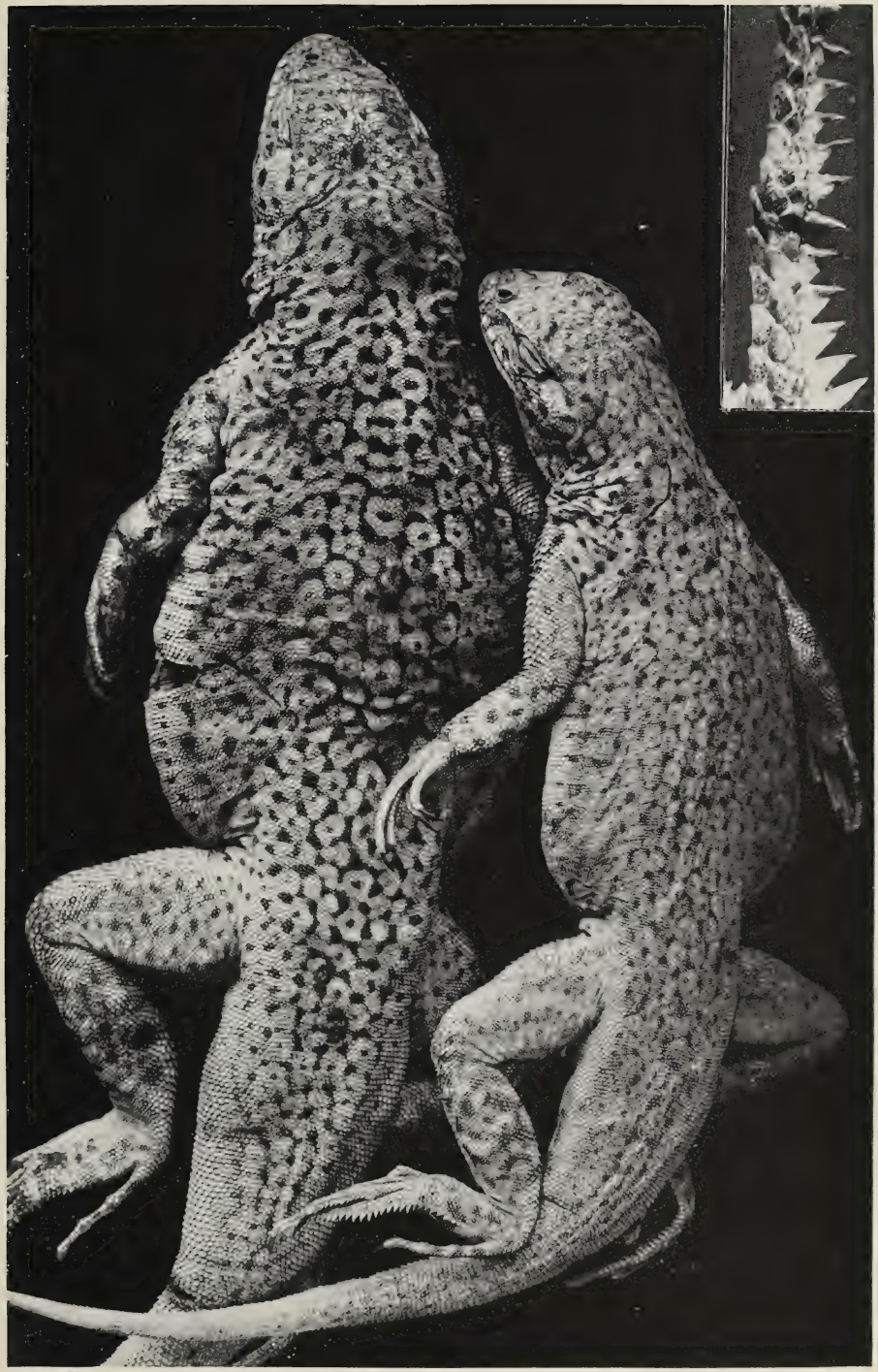

PLATE LIV

Fig. 1. *Phrynosoma coronatum* Blainville, U. S. N. M. No. 64465.

Fig. 2. *Phrynosoma blainvillii blainvillii* Gray, Field Mus. No. 1074, Trinidad, Lower California.

Fig. 3. *Phrynosoma nelsoni*, new species, paratype, Field Mus. No. 1127, San Quintin, Lower California.

To show the character of the frontal scales.

1 2 3

PLATE LV

Phrynosoma jamesi, new species, U. S. N. M. No. 64450, type.

PLATE LVI

Phrynosoma jamesi, new species, A. M. N. H. No. 5497, paratype. Enlarged views of head.

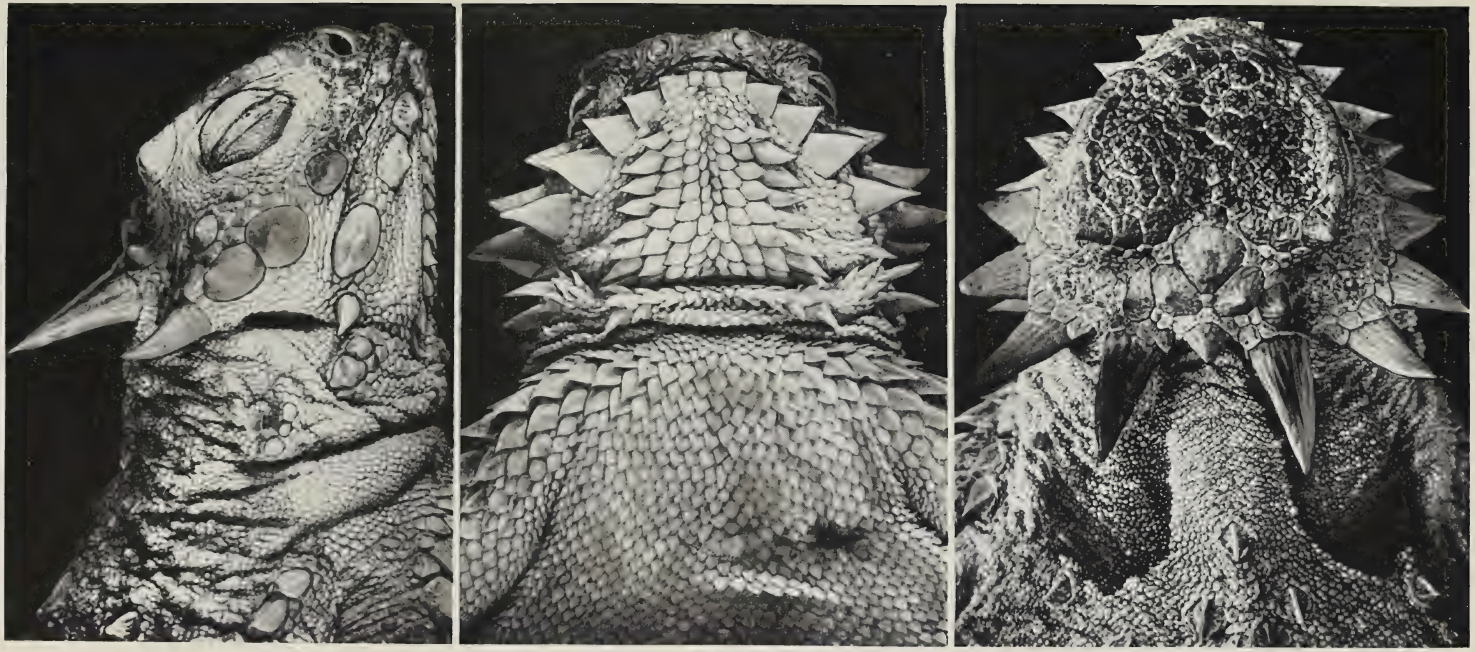

PLATE LVII

Cnemidophorus celeripes Dickerson, U. S. N. M No. 64444, San José Island.

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Article XII.—A REVIEW OF THE NORTH AMERICAN GENUS OF LIZARDS *HOLBROOKIA*

By Karl Patterson Schmidt

Plates LVIII to LX

The taxonomy of the North American lizards of the genus *Holbrookia* Girard offers one of the most interesting and difficult problems in North American herpetology. The American Museum of Natural History is in possession of extensive series of the species of *Holbrookia* acquired primarily through the interest and efforts of Miss Mary C. Dickerson, former Curator of the Department of Herpetology. These have been accumulated by purchase from San Antonio, Texas; by purchase from Mr. R. D. Camp of collections from Brownsville, Texas, and the Huachuca Mountains, Arizona; from department expeditions of Ruthven (1906) and Dickerson (1912); and by gift from Mr. Charles Lewis Camp of specimens collected in northern and central Arizona while connected with an expedition of the Museum of Paleontology of the University of California.

In addition to the American Museum material, the United States National Museum, through the kindness of Dr. Leonhard Stejneger, has loaned extensive collections of *Holbrookia* from Mexico and Arizona for comparative study.

The identification of this material has necessitated an examination of the genus, with considerable changes in the current views, which are primarily those of Stejneger (1890), Cope (1900), and Stejneger and Barbour (1917). Advance diagnoses of two new species and a new subspecies of *Holbrookia*, and a key to the species of the genus as understood by me, have already been published in a preliminary paper (1921, Amer. Mus. Nov., No. 22). It is the purpose of the present paper to complete the description of the new forms and to present the facts on which conclusions involved in the key to the species are based. Mr. C. L. Camp has kindly permitted me to insert his field notes on the two forms collected by him in Arizona in 1921. Field observation on the habits of all the species of *Holbrookia* are much to be desired and will throw light in turn on the taxonomic problems. Various notes by Strecker in his papers on the herpetology of Texas form the most important source of information I have found on life histories. It is hoped that the publication of a preliminary revision may facilitate the investigation of the numerous remaining problems in the distribution of the species to which I have called attention below.

The study of *Holbrookia* is attended by the greatest difficulty. There is scarcely a character employed for the distinction of the species which is not of a comparative nature, often differing in the sexes, so that it is practically necessary to have good series of the several species in hand at the same time in order to distinguish them. The present material is insufficient in many cases for more than a tentative conclusion as to specific limits. As far as possible, I have endeavored to remedy the want of definite characters by establishing the limits of variation in each form for the tail-length, the length of the hind leg, the number of ventral scales from collar to anus, and the number of femoral pores in the series available for study. A careful examination of the tabulation of these characters, together with the geographical limits proposed for the species, will probably be of more value for the determination of the species than the key, which can not be relied upon for critical specimens of the more closely allied forms.

The forms recognized by me are the following:

1. *Holbrookia texana* (Troschel)
2. *Holbrookia propinqua* Baird and Girard
3. *Holbrookia elegans* Bocourt
4. *Holbrookia pulchra* Schmidt
5. *Holbrookia lacerata* Cope
6. *Holbrookia maculata maculata* Girard
7. *Holbrookia maculata flavilenta* Cope
8. *Holbrookia maculata campi* Schmidt
9. *Holbrookia maculata approximans* Baird
10. *Holbrookia dickersonæ* Schmidt

All of these except the last are found within the limits of the United States.

I have not attempted a full bibliography, chiefly on account of the past uncertainty in the identification of the species. An accurate arrangement of the references under the proper specific headings would require a re-examination of the material on which the literature of the genus is based, and this is not at present possible. The present paper is to be regarded primarily as the result of the study of the material in my hands, and it is hoped that further studies of the distribution of the species may follow. Under each species I have cited the original description and the status assigned to it by Stejneger and Barbour in the 'Check List of North American Amphibians and Reptiles,' 1917.

For the present purpose, the genus may be sufficiently defined as the North American iguanid lizards with undifferentiated head plates, fine uniform dorsal scales, no dorsal crest, a well-defined denticulate collar preceded by a transverse fold, imbricate supralabial scales, a long series of femoral pores, and a concealed tympanum. All of the species have normally two or more lateroventral black spots more or less surrounded

by blue, and a spotted dorsal coloration, with two or four longitudinal rows of large dorsal spots (sometimes confluent transversely) darker than the ground color.

The relations of *Holbrookia* with the allied iguanid genera are not considered in the present paper.

Key to the Species

1. Tail flat with broad black ventral bands; lateroventral black marks placed far back, continued dorsally above the lateral fold. (Central Texas to south and central Arizona.) ..... *texana.*
   Tail rounded; no black bands beneath tail (small black spots in one species); lateroventral marks more anterior, not present dorsally ..... 2.
2. Tail longer than the body in both sexes ..... 3.
   Tail shorter than the body in the female, usually also in the male ..... 5.
3. Dorsal scales very small, convex or keeled; a distinct area of supraocular granules between the enlarged supraoculars and the frontals; tail very long; dorsal spots usually indistinct. (Southern Texas.) ..... *propinqua.*
   Dorsal scales larger, flat; no distinct small supraoculars between the frontals and the central supraoculars; dorsal spots usually (not invariably) distinct, sharply outlined ..... 4.
4. Size large, habitus robust, body frequently exceeding 60 mm.; femoral pores usually 12 or more. (Lower altitudes, Tucson, Arizona south along west coast of Mexico through Sinaloa.) ..... *elegans.*
   Size smaller, habitus slender, body less than 60 mm.; femoral pores usually less than 12. (High altitudes, above 5000 ft., Huachuca Mts., to Nogales and Bisbee, Arizona.) ..... *pulchra.*
5. Subcaudal black spots usually present; scales flat, not tubercular in large specimens; dorsal spots very sharply defined, often digitate behind. (Coahuila, Mexico, southern and central Texas, possibly to Kansas.) ..... *lacerata.*
   Dorsal spots rarely sharply defined; no subcaudal black spots; scales keeled or tubercular in large specimens ..... 6.
6. Three lateroventral black spots entirely surrounded by a blue patch. (Southern Coahuila, Mexico.) ..... *dickersonæ.*
   Two or three lateroventral black spots, often margined with blue, but no extensive blue patch ..... *maculata*–7.
7. Snout somewhat pointed, labials narrow, elongate; usually three or four scales between the enlarged nasals; a mid-dorsal light stripe usually and two dorsolateral and two lateral light stripes frequently present. (Wyoming and Nebraska, south to Texas.) ..... *maculata maculata.*
   Snout more truncate, labials shorter, wider, and more oblique to the horizontal; usually two or three scales between the enlarged nasals; no mid-dorsal light stripe ..... 8.
8. Usual dorsal pattern indistinct, replaced by small irregular light and dark spots; ground color very pale. ("White Sands" of southern New Mexico.) *m. flavilenta.*
   Large dark dorsal spots present, ground color darker ..... 9.

9. Tail shorter, .42–.50 of total in male, .42–.48 in female; hind leg shorter, .72–.83 in male, .65–.78 in female. (Northern Mexico, southern Arizona, southern New Mexico.) ..... *m. approximans.*

Tail longer, .48–.51 in male, .46–.50 in female; hind leg longer, .79–.86 in male, .77–.88 in female. (Central and northern Arizona, probably the Colorado Plateau.) ..... *m. campi.*

General Remarks on the Distribution of the Genus

The more general features of the distribution of the genus offer some interesting considerations. *Holbrookia* is obviously directly related to *Callisaurus*, from which it differs only in the concealed tympanum and with which it agrees in general features of color pattern and scutellation. In a general way, the ranges of *Holbrookia* and *Callisaurus* are complementary, overlapping only in a narrow area in Arizona and Sonora. Most of the species of *Holbrookia* have a complementary arrangement. The *maculata* group, which may be distinguished by the convexity of the dorsal scales, occupies the Mexican Plateau and extends northward into Arizona, New Mexico, western Texas, and the Great Plains. Two species have a peripheral distribution bordering the range of *maculata*, *lacerata* on the eastern border, *elegans* on the western. *Holbrookia pulchra* occupies the higher altitudes in the mountains of the southern border of Arizona, surrounded by *maculata approximans* on the mesas at the foot of the mountains. The range of *Holbrookia dickersonæ*, in southern Coahuila, is imperfectly known but may prove also to border that of *maculata*. *Holbrookia propinqua*, in southern Texas, occupies another area on the border of the range of *maculata*, practically to the exclusion of other forms. Finally, the range of *Holbrookia texana* has apparently no relation to that of the other species, occurring in a broad belt from central Arizona to central Texas and Nuevo Leon.

The great extent of the ranges of *maculata* with its several subspecies and of *texana* is striking when compared with the limited areas occupied by all of the remaining forms and may be taken to indicate the present dominance of *maculata* and *texana* and the decline of the remaining forms, which appear to have been forced toward the borders of the range of the genus.

Critical List of Species

Holbrookia texana (Troschel)

Cophosaurus texanus Troschel, 1852, Arch. Naturg., I, (1850), p. 389, Pl. vi (actually published in 1852).

Holbrookia texana Stejneger and Barbour, 1917, 'Check List of N. Amer. Amph. Rept.,' p. 49.

Holbrookia maculata approximans (part) Ruthven, 1907, Bull. Amer. Mus. Nat. Hist., XXVII, p. 526.

This species, the most distinct in the genus, is immediately distinguished by the conspicuous broad black bands on the under surface of the flattened tail, which is carried curled up when running. In the field, it is difficult or impossible to distinguish it from a *Callisaurus*. It is further characterized by the posterior position of the lateroventral black spots which are long and frequently continued well up on the dorsal surface.

Holbrookia texana ranges from central Texas to central Arizona. Strecker (1915, Baylor Bull., XVIII, No. 4, p. 17) defines its ranges in Texas, where it is apparently abundant in the Trans-Pecos region and sporadic in the eastern portion of its range.

Fig. 1. *Holbrookia texana*, head from the side; A. M. N. H. No. 2465, Catalina Mts., Ariz. × 2.

The record of the synonymous *H. affinis* from Sonora by Baird (1859, 'U. S. Mexican Boundary Survey, Reptiles,' p. 8) is an early indication of the occurrence of *H. texana* in the western part of its range. Van Denburgh (1896, Proc. Cal. Acad. Sci., (2) VI, p. 339) records it from Fort Lowell in southern Arizona. In a later paper (1913, Proc. Cal. Acad. Sci., (4) III, p. 399) the same author records it from the Catalina Mountains, north of Tucson, and from Cave Creek, Maricopa County. Specimens in The American Museum of Natural History from near Kirkland, Arizona, collected by C. L. Camp, July 5, 1921, appear to be the most northwesterly record for the species. In New Mexico, it is said not to range north of Socorro (Herrick, Terry and Herrick, 1899, Bull. Sci. Lab., Denison Univ., XI, p. 123). In Mexico, it ranges south to Monterey in Nuevo Leon, and Lerdo in Durango (Gadow, 1905, Proc. Zoöl. Soc. London, p. 213). In the western part of its range, specimens of *texana* have a somewhat higher number of femoral pores, and Strecker (1909, Baylor Bull., XII, p. 12) has called attention to a striking difference in coloration (in life) between specimens from Brewster County, Texas, and those from central Texas. It is probable that two fairly distinct subspecies of *texana* will be recognizable when sufficient material from all parts of its range is examined.

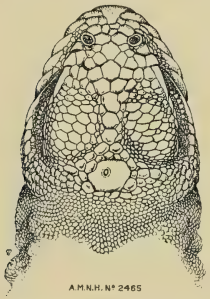

Fig. 2. The same, from above.

July fourth and fifth, 1921, were spent at Kirkland, Arizona. On the afternoon of the fifth I found *Holbrookia texana* abundant among the rocks and bushes in sandy ground along the south side of the sandstone cliffs just south of town. Often these lizards would climb onto stones and the lower ledges of the cliff as if to get a better view of the pursuer. A peculiar thing was that out of a considerable number of individuals seen (perhaps twenty) only two were males—easily distinguished by their much larger size and more striking coloration. It is possible that polygamy may occur in this species. (C. L. C.)

Holbrookia propinqua Baird and Girard

Plate LVIII

Holbrookia propinqua Baird and Girard, 1852, Proc. Acad. Nat. Sci. Phila., VI, p. 126; Stejneger and Barbour, 1917, 'Check List N. Amer. Amph. Rept.,' p. 49.

This species is satisfactorily defined by Cope (1900, Rept. U. S. Nat. Mus., 1898, p. 289, fig. 31). The coloration is often very nearly uniform, the dorsal spots very indistinct. There may be three or four lateroventral black spots, three specimens out of nineteen having more than two. The dorsal scales are very small, smaller than in any other *Holbrookia*; the tail is longer than in any other species; and the number of femoral pores is higher.

The range of this species is curiously restricted. The limits of the range given by Strecker (1915, Baylor Bull., XVIII, p. 18) are Refugio and San Antonio, west to the Pecos and south to the Rio Grande. The American Museum of Natural History has large series from San Antonio, Brownsville, and Padre Island (opposite Brownsville) in Texas. There seems to be no valid Mexican record of *propinqua*,[1] and it would be highly interesting to verify the limitation of its distribution by the Rio Grande. In large series received through several years from San Antonio, the only species of *Holbrookia* recorded were *propinqua*. *H. propinqua*, therefore, practically occupies its specific area to the exclusion of other members of the genus.

The records of *propinqua* from west Mexico (Boulenger, 1885, 'Cat. Lizards Brit. Mus.,' II, p. 208, and Garman, 1887, Bull. Essex. Inst., XIX, p. 131) doubtless refer to specimens of *H. elegans*.

Holbrookia elegans Bocourt

Holbrookia elegans Bocourt, 1874, 'Miss. Sci. Mex. Rept. Batr.,' p. 164, Pl. xvii, bis, fig. 8, 8*a*; Cope, 1900, Rept. U. S. Nat. Mus., 1898, p. 286.

Holbrookia maculata approximans (part) Ruthven, 1907, Bull. Amer. Mus. Nat. Hist., XXIII, p. 525.

Holbrookia thermophila Barbour, 1921, Proc. N. England Zoöl. Club, VII, p. 79.

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[1] U. S. N. M. No. 58446, labeled simply Chihuahua, J. Hurter, may be a juvenile *propinqua*.

Considerable confusion has existed in the records of *Holbrookia* from western Mexico. Specimens in The American Museum of Natural History and the United States National Museum from the type locality of *elegans* (Mazatlan, Sinaloa, Mexico) agree excellently with the original description. The excellent figure given by Bocourt shows the character of the supraoculars to which Barbour (*loc. cit.*) has called attention in describing *H. thermophila*, i.e., the absence of small granular scales between the enlarged supraoculars and the frontals. Cope, by placing *elegans* in the section of the genus with tail shorter than body, in spite of the fact that the tail of the type was stated to be reproduced, contributed to the confusion.

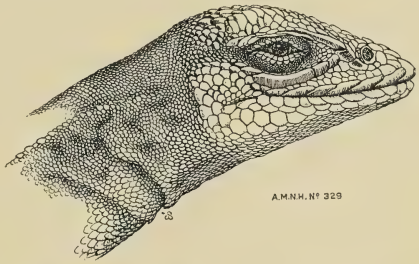

Fig. 3. *Holbrookia elegans*, head from the side; A. M. N. H. No. 329, Tucson, Ariz. × 2.

H. elegans is characterized by large size and robust habitus; the dorsal scales are flat and smooth; the scales between the enlarged frontals and the enlarged supraoculars are large, scarcely differentiated from either; the tail is round, longer than head and body in both sexes, without spots inferiorly; the femoral pores are fewer than in *propinqua*, considerably more than in *Holbrookia maculata approximans* or *H. pulchra*.

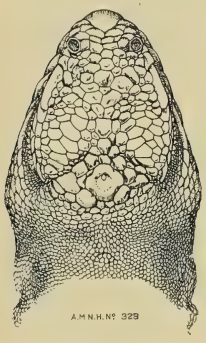

Fig. 4. The same, from above.

I am unable to find specific differences between the specimens from Sinaloa and topotypes of *H. thermophila* from Guaymas, Sonora, nor between these and specimens collected by Ruthven and Dickerson west of Tucson. Dr. Thomas Barbour has kindly placed a paratype of *H. thermophila* in the collection of The American Museum of Natural History, and he has elsewhere recorded his concurrence with my conclusion that it is identical with *H. elegans* (1921, Proc. New England Zoöl. Club, VII, p. 113). The spots are slightly less sharply outlined in the northern specimens, especially on their anterior border, otherwise they are practically identical.

Holbrookia elegans ranges from Escuinapa, Sinaloa, to Tucson, Arizona, along the west coast of Mexico. Specimens in the United States National Museum come from near Mazatlan, Bacubirito, and

Rosario, Sinaloa, and Batamotal, Sonora; in The American Museum of Natural History are specimens from Escuinapa and Mazatlan, Sinaloa, Guaymas, Sonora, and from Tucson, Arizona. This distribution is almost exactly paralleled by that of *Uta lateralis* Boulenger, which does not, however, reach the Arizona border.

Holbrookia pulchra Schmidt

Plate LIX

Holbrookia pulchra Schmidt, 1921, Amer. Mus. Nov., No. 22, p. 1.

Diagnostic Characters.—A slender, medium-sized species, allied to *H. elegans*, with tail considerably longer than the body, the hind leg averaging about four-fifths of the body length; dorsal scales flat; ventral scales large, 59 to 70 from collar to anus; femoral pores few, average 11.6; dorsal spots usually sharply defined, the dorsal and lateral series often confluent, enlarged supraoculars and frontals separated by scales not much smaller than either.

Range.—Huachuca Mountains of southern Arizona, east of Nogales.

Type.—A. M. N. H. No. 14777; Carr Canyon, 5200 ft.; Huachuca Mountains, Arizona; May 14, 1919; R. D. Camp.

Description of Type.—

Habitus slender, with tail longer than the body and long limbs; head scales flat, the scales between the enlarged supraoculars and the frontals about half as large as either; dorsal scales flat, smooth; ventral scales large, sixty from collar to anus; about eight pointed scales on each half of the collar, which is notched on the midline; labials elongate, keeled; femoral pores 11–12.

Color above dark grayish brown with a prominent series of darker spots, sharply defined posteriorly, on each side of the vertebral line; nine spots from the neck to the base of the tail; two more pairs of spots on the base of the tail, followed by five median spots; a series of lateral dark spots, similar to the dorsal spots, on each side; two prominent black lateroventral bars on each side, midway between axilla and groin, surrounded by light blue; venter entirely light; throat with a reticulation of heavy dark lines.

Measurements of Type.—Length, 120 mm.; body, 56 mm.; tail, 64 mm.; tail/total length, .53; foreleg, 28 mm.; hind leg, 47 mm.

Notes on Paratypes.—

The variations in measurements are incorporated in the table below. The degree of development of supraocular granules between the enlarged supraoculars and the frontals is highly variable, some specimens approaching the *elegans* type, some nearly like *propinqua* in this respect (U. S. N. M. Nos. 14749 and 19432). The coloration is variable. In A. M. N. H. No. 14740, the dorsal and lateral spots are united, forming wavy transverse lines separated only on the vertebral line. In many specimens, the dorsal spots are reduced to U or W-shaped lines, and may be more numerous from neck to rump (12 in A. M. N. H. No. 14736). Between this type and specimens (of both sexes) with a perfectly uniform olive-gray dorsum there are numerous intermediates with faint dorsal spots. The lateral spots in the type are margined with blue. In several male paratypes, the spots are placed in a vivid blue area covering half the distance between the axilla and groin. Three specimens have three distinct black lateroventral bars on each side. The dorsal spots are usually very distinct in

small specimens (A. M. N. H. No. 14741 forms an exception) somewhat outlined posteriorly with light spots.

Fifty-four specimens in The American Museum of Natural History, and twenty-one in the United States National Museum form the type series of this species. Specimens in the American Museum come from the following localities: Bisbee, Arizona (A. M. N. H. Nos. 307–312, 9039–9040); Hunter, Miller, Carr, Moore and Montezuma Canyons, 4600–6200 ft., Huachuca Mountains, Arizona, April 14–June 20, 1919, (A. M. N. H. Nos. 7776–7779, 7792–7799, 14593–14594, 14597, 14701 14703–14709, 14713–14714, 14719, 14721–14722, 14733, 14736–14737, 14739–14744, 14749–14750, 14781, 14783, 14788, 14894). Specimens in the United States National Museum are from Nogales, Arizona (Nos. 16980, 17227–17233 and 46980); Mexican Boundary (Nos. 19371–19373 and 19432); Tucson (No. 13973). Fort Buchanan (No. 5025); Fort Huachuca (No. 14749) and "Mexico" (Nos. 47423–5).

It is evident that this species has been confused with *Holbrookia maculata approximans*, to which I have referred a large series of specimens in part from the same localities. Stejneger (1890, N. Amer. Fauna, No. 3, p. 109) has apparently included specimens of both *pulchra* and *approximans* under the latter, and I believe that the character used by him to distinguish *approximans*, the more posteriorly situated lateroventral spots, is derived from specimens of *pulchra*. The description of *approximans* given by Cope (1900, Rept. U. S. Nat. Mus., 1898, p. 297) is evidently based on specimens of *pulchra*, except for the portions copied from Baird's notes. The original description of *approximans* states distinctly that the tail is shorter than the body; "the light blue areola" scarcely indicates the extensive blue patch of *pulchra*, and the type locality, Lower Rio Grande, corresponds well with the specimens from northern Mexico which I have referred to *approximans*. The eastern limit of the range of *pulchra* so far determined is Bisbee, Arizona, and I do not believe it will be found to enter the Rio Grande drainage.

When the Huachuca Mountain specimens of *Holbrookia* are separated into two series, the long-tailed, flat-scaled *pulchra* and the short-tailed, tubercular-scaled *maculata approximans*, a difference in altitudinal distribution is shown. *H. pulchra* ranges from 4600 feet to 6200 feet, but there is only one specimen from the lowest altitude, all the rest coming from above 5000 feet. *H. m. approximans* ranges from 4300 feet to 6200 feet, with but only one specimen from the highest level, nine from about 5000 feet, near the mouths of canyons, and forty-four from localities on the mesa, one or two miles from the mouths of the canyons, at 4300 to 4400 feet.

Holbrookia pulchra is most closely allied to *H. elegans*, whose northward range into Arizona has been indicated above. It is not improbable that *pulchra* may ultimately be referred to subspecific rank as a sub-

species of *elegans*, as the chief characters which distinguish the two forms are size and number of femoral pores, with a somewhat different range in coloration. I am not at present able to determine whether the ranges of *H. elegans* and *pulchra* are contiguous.

Holbrookia lacerata Cope

Holbrookia lacerata Cope, 1880, Bull. U. S. Nat. Mus., No. 17, p. 15.
Holbrookia maculata lacerata Stejneger and Barbour, 1917, 'Check List N. Amer. Amph. Rept.,' p. 49.

I have examined six specimens of this species in the United States National Museum. Although I fully agree with Stejneger (1890, p. 110) as to the difficulty of distinguishing certain *H. lacerata* from *H. maculata maculata*, I regard *lacerata* as specifically distinct. The most distinctive color characters, the presence of subcaudal black spots in both sexes, and the absence of lateroventral black spots in the male are not invariable; two of the seven specimens before me lack the subcaudal spots and the lateroventral spots are absent in two specimens, faint in two, and distinct in two. Most specimens are characterized by perfectly flat, smooth scales, considerably larger than in *maculata maculata*; but one large specimen (U. S. N. M. No. 46697) from Sabinas, Coahuila, Mexico, while agreeing exactly in coloration with *lacerata*, has the small tuberculate scales of *maculata maculata* or *maculata approximans*. The flat scales seem to relate *lacerata* to the *elegans-pulchra* group of *Holbrookia*. It is possible that, although genetically distinct from *maculata*, it may occasionally hybridize with it, as the specific distinctions in *Holbrookia* are admittedly close.

The distribution is interesting and somewhat uncertain. Specimens recorded by Cope from Neosho, Kansas, were previously referred to *H. maculata maculata* by Stejneger (1890, *loc. cit.*). Authentic localities in Texas are in three groups: (1) Crockett County, southwestern, near the lower Pecos; (2) Kerr, Kendall, and Bexar Counties, southeastern; (3) and McLennan, Erath, and Comanche Counties, northeastern. I have noted a specimen from Coahuila, Mexico, above.

From the evident rarity of this species and the widely separated localities in which it has been found, I infer that it is a species declining in numbers. It is interesting that the range of *lacerata* borders that of *maculata* on the east from Kansas to San Antonio, from which it might be inferred that *lacerata* was formerly a great plains' species, being crowded out by the dominant *maculata maculata*, which has probably spread northward on the plains with the arrival of the present climatic conditions.

Holbrookia maculata maculata Girard

Holbrookia maculata Girard, 1851, Proc. Amer. Soc. Adv. Sci., IV, p. 201.
Holbrookia maculata maculata Stejneger and Barbour, 1917, 'Check List N. Amer. Amph. Rept.,' p. 48.

There is, fortunately, no uncertainty as to the identity of the typical subspecies of *Holbrookia maculata*. The type locality, opposite Grand Island, Platte River, Colorado, is sufficiently near the northern boundary of the range to preclude any possibility of confusion with the subsequently described related forms.

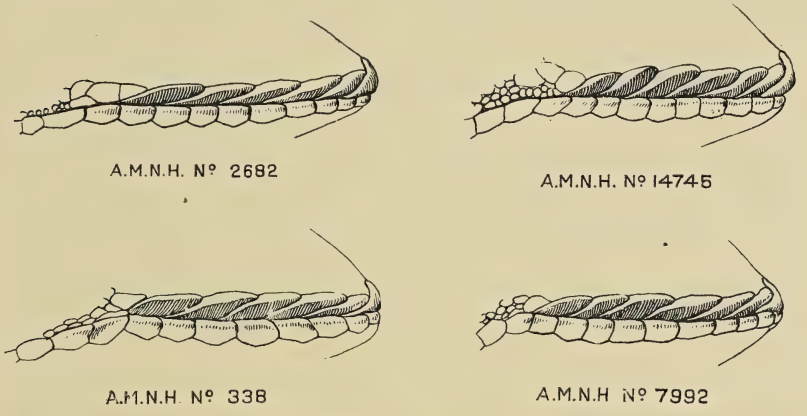

Fig. 5. Labial scales of the four subspecies of *Holbrookia maculata*. A. M. N. H. No. 2682, *Holbrookia maculata maculata*, Wilson County, Kansas; A. M. N. H. No. 338, *H. m. flavilenta*, White Sands, Alamogordo, New Mexico; A. M. N. H. No. 14745, *H. m. approximans*, Huachuca Mountains (4900 ft.), Arizona; A. M. N. H. No. 7992, *H. m. campi*, Adamana, Arizona. The shorter contact of the labials with the labial border allows room for six labials in the latter two, compared with five in the two former.

Holbrookia maculata is in general characterized by a short tail, a character which distinguishes it fairly well from all of the species of *Holbrookia* except *lacerata* and *dickersonæ*. From *lacerata* it is distinguished by the tubercular, subcarinate scales and the coloration; from *dickersonæ* by the absence of the blue lateral patches in which the latero-ventral black markings of that species are placed.

The characteristic coloration of the subspecies *maculata maculata* has been noted by Cope (1900, p. 293); there is usually a fairly distinct light mid-dorsal line and two dorsolateral lines, separating the dorsal series of markings, which thus appear to lie in a broad band of ground color. This color character separates it from the other subspecies of *maculata*.

In all of the subspecies of *maculata*, the females usually have distinct lateroventral spots. In a series of nineteen females of *m. maculata* from Colorado (A. M. N. H. Nos. 1453–1471), ten have two spots on each side, four have two on one side and three on the other, five have three on each side, and one has three on one side and four on the other.

Structurally, *m. maculata* is distinguishable from *m. approximans* and *m. campi* by having more slender and elongate upper labials, which are usually fewer in number. From *m. approximans* and *m. campi* and *m. flavilenta* as well, it is distinguished by a tendency to have smaller scales on the upper surface of the snout, usually three or four scales between the enlarged supranasals, while the other three subspecies usually have two or three internasal scales.

The distribution of this subspecies is well defined at the north, where it is the only *Holbrookia*. It is primarily a Great Plains form, occurring in southern Wyoming and all of Colorado east of the Rocky Mountains, ranging east into the adjacent parts of Nebraska and Kansas, and south into Oklahoma and northern Texas. Strecker (1915, Baylor Bull., XVIII, p. 17) defines the eastern border of its range in Texas by means of Wichita, Parker, and Bexar Counties. From his description of specimens from the plains region, Hockley, Yoakum, and Garza Counties (1909, Baylor Bull., XII, p. 12), it is evident that *m. maculata* is the typical *Holbrookia* of the Llano Estacado. The specimens from Brewster County, discussed under the same heading (*loc. cit.*), are noted as different from the plains form. It is possible that the Trans-Pecos *Holbrookia maculata* is really *approximans*. It is equally possible that *flavilenta* of southern New Mexico is the subspecies inhabiting the Rio Grande valley and will not prove to be confined to sandy areas as I have provisionally supposed (below).

Holbrookia maculata flavilenta Cope

Holbrookia maculata var. *flavilenta* Cope, 1883, Proc. Acad. Nat. Sci. Phila., p. 10.
Holbrookia maculata flavilenta Ruthven, 1907, Bull. Amer. Mus. Nat. Hist., XXIII, p. 525.

Stejneger (1890, N. A. Fauna, No. 3, pp. 109–110) has (provisionally) applied the name *flavilenta* to the race of *Holbrookia maculata* which occupies the northern portion of the plateau region, including northern Arizona and western New Mexico, distinguishing it from *approximans*, which borders its range on the south, by the more posteriorly situated lateroventral spots in the latter subspecies.

The original description of Cope, repeated in the revision of 1900 (Rept. U. S. Nat. Mus., 1898, p. 292) of "dorsal spots obscure or wanting,

back yellow speckled" applies exactly to a series of six specimens collected by Ruthven at Alamogordo, New Mexico, about one hundred miles east of the type locality (Lake Valley, New Mex.). Specimens from the Colorado Plateau do not have this coloration, or have it only exceptionally; and to this plateau form I have applied a new name.

The labials of the six specimens of *flavilenta* collected by Ruthven are decidedly more elongate than those of *m. approximans*, and in this respect they approach *m. maculata*. In correlation with this character, the number of upper labials, counted to include the last one which exceeds the adjacent lower labial in size, is less than in *m. approximans* or *m. campi*, which usually have six labials. In the six *m. flavilenta*, five labials occur nine times, six labials three times. In *m. campi*, five occur six times, six occur fourteen times.

From Ruthven's account of the occurrence of *flavilenta* at Alamogordo, it is nearly, if not entirely, confined to the peculiar habitat conditions of the White Sands, where he found it to be abundant, while it was not collected in any other habitat association. It would appear that the sands offered more favorable conditions for the local *Holbrookia*, and, as it were, attracted them from the surrounding areas. If similar habitat conditions are found at Lake Valley, *flavilenta* may be considered as a permanent adaptive color variety occurring in the more or less isolated areas where loose sands prevail.

Pending further investigation of this extremely interesting case, I prefer to restrict the name *flavilenta* as above.

Holbrookia maculata approximans Baird

Plate LX

Holbrookia approximans Baird, 1858, Proc. Acad. Nat. Sci. Phila., p. 253.
Holbrookia maculata approximans Stejneger and Barbour, 1917, 'Check List N. Amer. Amph. Rept.,' p. 48.

Under this name I have included a somewhat variable assemblage of *Holbrookia* from the Mexican Plateau and a very uniform series of fifty-eight specimens from the Huachuca Mountains, Arizona.

Stejneger (1890, N. Amer. Fauna, No. 3, p. 109) distinguishes *approximans* + *flavilenta* from *maculata* by the greater truncation of the snout, the greater width, height, and obliqueness of the labials (with which is correlated an increased number of labials), and the reduced number of scales on the snout. These characters distinguish the *approximans*, and *campi* of the present paper, *flavilenta* occupying an intermediate position. The latter character may be defined by means of the number of scales between the enlarged nasals. These average 2.5 in

ninety-six specimens of *approximans*, 3.0 in ten *campi*, 2.8 in eight *flavilenta*, and 3.5 in thirty-eight *maculata*, i.e., the internasals are usually either two or three in *approximans*, usually three in *flavilenta* and *campi*, and either three or four in *maculata*.

In both the form of the labials and the size of the internasals, *approximans* and *campi* are more closely related *inter se* than to *maculata*. *Holbrookia m. approximans*, the most widely distributed, most southern, and most variable subspecies, is probably to be considered the stock from which *maculata* and *campi* have become differentiated.

The reasons for distinguishing *flavilenta* have been stated above. From *campi*, *approximans* as here restricted (by the exclusion of the Huachuca *pulchra* and the Tucson *elegans*) is distinguished by differences in the tail length and the length of the hind leg, especially in the females (see table of variation below).

The most striking variation within the series of *approximans* is the greater number and frequently the indefiniteness and smaller size of the dark dorsal spots in the specimens from the Huachuca Mountains. A single specimen, U. S. N. M. No. 30824, from between Ojos del Diable and Rio Santa Maria, Chihuahua, is very much larger, longer-tailed, and longer-legged than any other specimen in the series examined (fifty-four Mexican specimens and fifty-eight Arizonan). It is probably simply an unusually old and large male of *approximans*.

The series at hand contains specimens from Jesus Maria, southern San Louis Potosi (U. S. N. M. No. 47163, E. W. Nelson), Berriozobal, southern Zacatecas (U. S. N. M. Nos. 46867–8, Nelson and Goldman), Guanajuato (U. S. N. M. Nos. 9894, 9903, A. Dugés), and Durango (A. M. N. H. Nos. 1416–1418, J. H. Batty). These records probably define approximately the southern limits of the range of *approximans*. It is abundant in Chihuahua and Coahuila, and doubtless also in parts of Sonora and Nuevo Leon. In the southwestern United States, the only records which I can verify are those from the lower altitudes in the Huachuca Mountains. Brown (1903, Proc. Acad. Nat. Sci. Phila., p. 545) regards *Holbrookia maculata* at Pecos, Texas, as *m. maculata*. Southwestern Texas and southern New Mexico should be the area of intergradation between *m. approximans* and *m. maculata*. Bailey (1913, N. Amer. Fauna, No. 35, p. 34) records *Holbrookia maculata*, *H. approximans*, and *H. flavilenta* as characteristic of the Upper Sonoran Life Zone in New Mexico, obviously without discrimination, and it is evident that a study of the New Mexican *Holbrookia* will clear up the status of the four subspecies of *maculata* at present known. It is probable that

another Mexican subspecies related to *approximans* will be recognizable when sufficient material is at hand. *Holbrookia propinqua*, recorded from the Lower Sonoran of New Mexico by Bailey (*loc. cit.*, p. 20), is probably *H. m. approximans*, as *approximans* was formerly so identified by Cope (see Stejneger, 1890, N. Amer. Fauna, No. 3, p. 109).

Holbrookia maculata campi Schmidt

Holbrookia maculata flavilenta (*non* Cope) Stejneger, 1890, North Amer. Fauna, No. 3, p. 109.

Holbrookia maculata campi Schmidt, 1921, Amer. Mus. Nov., No. 22, p. 1.

Diagnostic Characters.—Characters of *Holbrookia maculata*. Distinguished from *H. m. maculata* by coloration, which resembles that of *approximans*, and by the fewer, wider and more oblique upper labials, also as in *approximans;* distinguished from *m. flavilenta* by the same characters; distinguished from *m. approximans* by the longer tail and hind leg, especially of the female; tail/total length varies from .46 to .50 in ♀ *m. campi*, averaging .48, .42 to .48 in ♀ *m. approximans*, averaging .44; length of leg/body length ranges from .77 to .88 in ♀ *m. campi*, averaging .83, .65 to .78 in ♀ *m. approximans*, averaging .71.

Range.—Probably the southern part of the Colorado Plateau in northern Arizona. Apparently not reaching Utah on the north, possibly entering New Mexico to the east. It is expected that it will be found to intergrade with *m. approximans* in central Arizona.

Type.—A. M. N. H. No. 7990; ♂, about 8 miles N. W. of Adamana, Apache County, Arizona; June 21, 1921; Charles L. Camp.

Description of Type.—

Habitus of *Holbrookia maculata* with a rather stout body; tail usually shorter than the body; a short, wide, and high head; limbs rather long; dorsal scales small, distinctly convex; scales on the head numerous, with two rows of transversely enlarged supraoculars, enlarged scales on the snout, a very large occipital in contact with the median series of larger scales between the eyes; three scales between the enlarged supranasals; six enlarged and keeled upper labials which are set at a considerable angle to the horizontal; ventral scales much larger than the dorsals, in transverse rows, of which there are sixty-two from collar to anus; seven or eight enlarged scales in each half of the collar; femoral pores 12–13.

Ground color above slate gray, with two series of large dark dorsal spots, about eight on the body with two pairs more on the base of the tail; sides with numerous small yellow dots, a few of which extend dorsally among the dark markings; venter creamy white with two very distinct black spots on each side, the first half-covered by the adpressed elbow, very narrowly margined with blue.

Measurements of Type.—Total length, 101 mm.; body, 53 mm.; tail, 48 mm.; tail/total length, .48; arm, 25 mm.; leg, 42 mm.

Notes on Paratypes.—

The series of ten specimens, four males and six females, is very uniform in coloration and in structural characters. The variation in measurements is shown in the table below. The internasal scales are uniformly three, while in Huachuca *approximans* they are two in 50 per cent of the specimens examined.

The specimens recorded by Stejneger (1890, *loc. cit.*) as *Holbrookia maculata flavilenta* came from about a hundred miles west of the present locality, but there is no reasonable doubt that they are the same form. He distinguished them from *approximans* in southern Arizona, doubtless with a considerable proportion of specimens of *pulchra* in the series of *approximans* before him, as it is *pulchra* which has the more posteriorly placed lateroventral spots. I believe the form in northern Arizona to be most closely related to *approximans*, and to be fairly distinct (especially in the character of the labials) from *flavilenta*.

The plains, mesa and sparsely vegetated "bad-lands" in the "Petrified Forest" areas south of the railroad at Adamana, Arizona are slightly higher in elevation than some areas to the north, and northwest, farther down the course of the Little Colorado River. Desert conditions become increasingly prevalent as one passes northward from the slopes of the White Mountains into the Painted Desert area north of Holbrook.

Most of the time in the field (three weeks, June–July 1921) was spent at the Blue Forest, six miles south of Adamana. Only a single *Holbrookia* (No. 7986) was collected here. This specimen, the only one I saw in the vicinity, had been dropped near me by a small hawk which had killed the lizard by a severe blow on the back of the head.

During a single warm day (July 2, 1921) spent in the Carrizo wash, eight to fourteen miles northwest of Adamana, a large number of *Holbrookia* were seen and a series was collected. All were taken near or under small bushes in the hot, flat ground immediately above the low banks of the wash. None were noted on the mesas and uplands above. The lizards by remaining motionless and lying close to the light-colored soil often made themselves inconspicuous. If approached carefully they could sometimes be captured in the hand. A female lizard which had been wounded, ran under my feet, and a male, seeing her actively squirming, became excited and seizing the back of her neck in his teeth, attempted copulation, twisting one hind leg around the tail and inserting one hemipenis from the right side. The female was nearly dead and the male allowed himself to be captured without attempting escape. (C. L. C.).

Holbrookia dickersonæ[1] Schmidt

Holbrookia propinqua (part) Cope, 1900, Ann. Rept. U. S. Nat. Mus., p. 289.
Holbrookia dickersonæ Schmidt, 1921, Amer. Mus. Nov., No. 22, p. 2.

Diagnostic Characters.—A large, stout bodied species, with a slightly flattened tail equal to or slightly shorter than the body; snout very obtuse; dorsal scales small, slightly convex; small granular scales between the enlarged supraoculars and the frontals; labials very short and at a high angle with the horizontal, strongly keeled, strongly projecting; femoral pores 9–13; coloration of *H. m. approximans*, but with three lateroventral black spots entirely surrounded by a patch of blue, which is equally distant from axilla and groin and covers more than half the distance between.

Range.—Known only from Castanuelas and Alamos de Parras in the state of Coahuila, Mexico.

[1]Named for Miss Mary C. Dickerson, former curator of the Department of Herpetology, American Museum of Natural History.

Type.—U. S. N. M. No. 2668A[1]; Castanuelas, Coahuila, Mexico; Lieutenant B. Couch, U. S. A.

Description of Type.—

Habitus stout, head moderate, snout obtuse; tail slightly flattened, equal to the length of the body; hind leg about four-fifths the length of the body; head scales normal, slightly convex, the largest frontals somewhat larger than the enlarged supraoculars, separated from them by a patch of small granular scales; labials large, short, set at a high angle with the horizontal, strongly keeled, strongly projecting; dorsal scales nearly flat, more convex on the sides; ventral scales 82 from anus to collar; femoral pores 9–9.

Ground color above light grayish brown, with a double dorsal series of dark spots, which are rounded or somewhat emarginate behind, less distinctly defined on their anterior border; eight pairs of spots on the back, followed by three pairs on the base of the tail, behind which they are confluent as faint crossbands; an obscure lateral series of dark spots on each side interspaced with small light spots; entire ventral surface white, except for dark gray mottling on the throat and a broad blue patch on each side below the lateral fold; the blue patch extends about halfway to the mid-ventral line, nearly to the groin posteriorly, a little further from the axilla anteriorly; three black spots on each side in the blue patch, not sharply defined, the anterior just behind the adpressed elbow, the middle one largest, the posterior merely indicated as a round spot; limbs with dark spots or bands above.

Measurements of the Type.—Length, 116 mm.; body, 58 mm.; tail, 58 mm.; tail-length, .50; foreleg, 30 mm.; hind leg, 46 mm.

Notes on Paratypes.—The type series of six specimens, U. S. N. M. Nos. 2668 and 2664, shows little variation. Only two specimens have a complete tail, indicating a somewhat greater fragility than in *H. maculata*. In the larger specimens, the dorsal scales are much more tubercular. In one specimen, the dorsal color pattern is obscured anteriorly by an increase and invasion of the small light lateral spots.

I believe this species to be directly related to *Holbrookia m. approximans*, from which it is distinguished by its coloration and proportions. The specimens on which this species is based are listed under *Holbrookia propinqua* by Cope (1900, p. 291), a species from which it is very distinct.

[1]U. S. N. M. No. 2668 covering four male specimens, I designate the type by means of a lettered tag A.

COMPARATIVE TABLE OF VARIATION THE SPECIES OF *Holbrookia*

Holbrookia	Sex	Total Length			Length of Body			Tail/To ength			Length of Hind Leg / Body Length			Number of Ventrals Collar to Anus			No. of Femoral Pores on Each Side		
		No. Spec.	Extremes	Mean	No. Spec.	Extremes	Mean	No. Spec.	Ext s	Mean	No. Spec.	Extremes	Mean	No. Spec.	Extremes	Mean	No. Spec.	Extremes	Mean
texana	♂	6	122–151	143	13	57–70	63	6	.52	.54	13	.82–.93	.87	13	71–88	79	13	10–19	14.4
	♀	6	113–132	123	6	53–63	58	6	.51	.53	6	.82–.93	.89	6	77–81	80	10	10–16	13.4
propinqua	♂	18	100–140	123	19	43–59	52	18	.56	.58	19	.77–.93	.82	19	67–87	76	19	13–19	16.2
	♀	25	99–127	115	25	43–56	49	25	.51	.55	25	.71–.91	.80	25	66–83	74			
elegans	♂	4	116–151	137	8	54–67	61	7	.51	.54	11	.71–.86	.80	9	61–76	68	11	11–15	13.4
	♀	6	114–137	127	9	53–65	60	6	.50	.52	10	.70–.81	.76	10	64–75	67	10	12–15	13.0
pulchra	♂	15	104–125	116	15	48–58	53	15	.51	.54	15	.74–.87	.82	15	58–66	62	23	10–15	11.6
	♀	9	95–117	107	9	47–56	52	9	.50	.52	9	.75–.83	.80	9	58–70	65	11	8–13	11.1
lacerata	♂	4	92–134	106	4	45–65	54	4	.48	.50	4	.71–.93	.79	4	64–75	68	4	12–16	13.7
	♀	1	108	108	2	53–60	56	1	.	.51	2	.75–.80	.78	2	70–73	72	2	13–14	13.8
maculata maculata	♂	7	95–107	101	8	48–58	52	7	.45	.48	8	.67–.83	.77	8	67–80	70	10	10–14	12.2
	♀	25	80–105	93	25	42–58	50	25	.42	.46	25	.64–.83	.72	15	63–73	67			
m. flavilenta	♂	1	99	99	1	49	49	1	.	.51	1	.84	.84	1	64	64	1	8–9	8.5
	♀	4	82–101	91	5	43–54	48	4	.46	.48	4	.70–.82	.77	3	65–69	67	5	7–14	10.6
m. campi	♂	4	90–111	98	4	44–54	50	4	.48	.50	4	.79–.86	.84	4	62–69	66	4	11–14	12
	♀	6	79–92	85	6	41–47	44	6	.46	.48	6	.77–.88	.83	5	62–70	65			
m. approximans	♂	17	92–111	102	17	47–59	49	17	.42	.48	17	.72–.83	.79	17	58–74	68	18	8–13	10.8
	♀	27	77–113	91	27	45–61	51	27	.42	.44	27	.65–.78	.71	27	62–74	67	12	9–13	10.5
dickersonæ	♂	1	116	116	5	47–72	59	1	.	.50	5	.72–.87	.81	5	73–82	77	5	9–13	10.9
	♀	1	121	121	1	58	58	1	.	.48	1	.72	.72	1	72	72	1	10	10

PLATES LVIII to LX

PLATE LVIII

Holbrookia propinqua. From left to right, A. M. N. H. Nos. 7685 ♀, 7686 ♀, 7688 ♂, 7687 ♀, 7689 ♂, 7670 ♂. San Antonio, Texas. Note the slender proportions of the species, and the spotted nuptial coloration of the males.

PLATE LIX

Holbrookia pulchra. From left to right, A. M. N. H. Nos. 14597 juv., 14713 ♂, 14705 ♀, 14701 ♂, 14894 ♀. Huachuca Mts., Arizona.

Plate LX

Holbrookia maculata approximans. From left to right, A. M. N. H. Nos. 14787 juv., 14770 juv., 14732, ♂, 14759 ♀, 14746 ♂, 14715 ♀. Huachuca Mts., Arizona.

Article XIII.—CURRENT PALÆONTOLOGICAL RESEARCH IN CHINA

By J. G. Andersson

The arrival in China of the Third Asiatic Expedition of the American Museum under the leadership of Mr. Roy Chapman Andrews, a gigantic enterprise with one of its main objects the study of fossil mammals and especially the ancestry of Man, has certainly created in American scientific circles an increased interest in the palæontological possibilities of eastern Asia.

The members of the American Museum Expedition have most cordially coöperated with the staff of the Geological Survey of China by dividing up the vast field of research and establishing a system of mutual support in an endeavor to avoid duplication of work. Moreover, Mr. Granger, the chief palæontologist of the American Museum Expedition, has put his superior technique generously at our disposal, while we on our side have offered our knowledge of local conditions for the orientation of our American colleagues.

Under these circumstances it is to be expected that the interest taken in the palæontological work of the American Museum's expedition will be extended also to the palæontological research carried on by the Geological Survey of China. In this hope I have prepared, after consultation with Mr. Granger and with my colleagues in the Survey, the following brief summary of our current research in palæontology and archæology.[1]

Much of the collecting work recorded below has been carried out by aid of funds provided from my native country, Sweden, through the good offices of a research committee headed by His Royal Highness, The Crown Prince of Sweden. According to the agreement made between Chinese and Swedish scientific authorities, the collections will be divided between the Geological Survey of China and Swedish museums.

The Swedish scientists, principally Professor Th. G. Halle of the State Museum in Stockholm and Professor C. Wiman of the University of Upsala, who have taken in hand the preparation and description of these collections, have agreed to have all the palæontological monographs prepared by them and their associates published in the Palæontologia

[1]I am much indebted to Dr. Grabau for important contributions to the section on invertebrate fossil research.

Sinica, a series of publications organized by the Director of the Geological Survey of China, Dr. V. K. Ting, and intended to include as far as possible descriptions and figures of all the fossils of China.

All invertebrate fossils from Palæozoic and Mesozoic formations are in totality handed to the Geological Survey to be described by the palæontologist of the Survey, Dr. A. W. Grabau.

In like manner all the human skeletal remains unearthed in our archæological excavations will remain in China, and the material already brought together has been taken over by Dr. Davidson Black, of the Peking Union Medical College, for description and publication in the Palæontologia Sinica.

Fossil Invertebrates

From a practical point of view, especially in stratigraphic investigations, the marine invertebrate fossils stand foremost in importance. It has been the good fortune of the Survey to secure the coöperation of one of the most eminent workers in the field of Palæozoic invertebrates, Dr. A. W. Grabau, formerly Professor of Palæontology at Columbia University, and since 1920 Palæontologist to the Geological Survey of China and Professor of Palæontology in Peking National University.

Dr. Grabau's long experience in Palæozoic invertebrate palæontology, coupled with his phenomenal capacity for work, has already resulted in the production of a number of monographs on different groups of Palæozoic fossils which will appear in the near future in the Palæontologia Sinica. It is to be expected that Dr. Grabau himself will put before American scientists a much more authoritative summary of his work. The following notes may be sufficient for the present purpose.

The first considerable collections of invertebrate fossils brought together by the Geological Survey were collected by the Director, Dr. V. K. Ting, during his travels in Yunnan in 1914–15. They comprise Cambrian, Silurian, Devonian, Carboniferous and early Mesozoic forms. The Cambrian fossils have been studied and determined by Dr. C. D. Walcott, and on some of the others Dr. Grabau has begun work.

On the progress of invertebrate palæontological research Dr. Grabau has kindly contributed the following statement:

> Before the arrival of Dr. Grabau there was no palæontologist at the Geological Survey, therefore the invertebrate fossils collected by the members of the Geological Survey in various parts of the country were sent to Illinois to be studied by a member of the Geological Survey of China under the guidance of Professor Savage. Un-

fortunately, this member became interested in economic geology and the collections were only very imperfectly studied. Recently this material is being sent back to China to be worked out by Dr. Grabau.

Extensive collections of invertebrate fossils have recently been made by Mr. E. Norin and Mr. C. C. Wang in connection with their study of the later Palæozoic formations of Shansi province; others have been brought in from these series by Dr. Andersson's private collectors. These fossils were obtained from a series of intercalated marine limestones in the continental coal-bearing formations and, as the position of these beds has been accurately ascertained in the measured sections, we will soon be able to develop a standard or type section for the later Palæozoic formations of North China.

Until recently very little had been known of the fauna of the thick Ordovician limestone of northern China. Frech had described the *Actinoceras* collected by von Richthofen, and Lorenz had specifically identified three species from Shantung. The material collected by Blackwelder was so imperfect that Weller could only make generic determinations. Recent collections in this formation have materially increased our knowledge of this fauna and, in the monograph on the 'Ordovician Fossils of North China' (Pal. Sinica, Sec. B, I, fascicle 1, 1922) just published, it is described at length by Dr. Grabau. There are now known from this formation 31 genera and 45 species, all except five of these being new.

A large collection of well-preserved fossils from the Ordovician of the Yangtze region has been sent to the survey by H. B. M. Consul, J. Langford Smith of Ichang. This contains a number of new species and the fauna will be described during the coming year.

It has been found desirable to make a comprehensive study of the Palæozoic corals of China with a revision of families and genera of Palæozoic corals in general, so far as accumulated material permits. Considerable progress has been made in this work, and the first fascicle of the monograph with one plate and 74 text figures is now in press (Pal. Sinica, Sec. B, II, fascicle 1). A second fascicle is far advanced.

Dr. Grabau is now at work on the description of the Devonian fossils of Yunnan collected by Dr. V. K. Ting and this will appear as fascicle 2 of Vol. I, Series B of the Palæontologia Sinica.

Of considerable interest is the discovery of a fairly complete though small specimen of *Eurypterus* in the coal measures of the Kaiping basin. This occurrence is in black shales, associated with plant remains, above a thin argillite with marine fossils of Lower Permian age. This is the

first *Eurypterus* found in China. A carapace of a new species of *Pterygotus(?)* has also been obtained from the coal series of Honan by Prof. J. S. Li.

Fossil Plants

Nearly every province of China is rich in coal deposits ranging in age from Palæozoic to early Tertiary. Several small collections from these formations were described by Schenk in Richthofen's monumental work 'China,' but thus far our knowledge of the fossil floras of China has remained exceedingly imperfect.

Just as Dr. Ting's collections of invertebrate fossils from Yunnan mark the beginning of research in that field by the National Geological Survey, so the plant fossils brought by him from the same region constitute the first collection of that kind made by the Survey. They represent several widely different geological horizons, and among them several specimens of Devonian plants are of especial interest.[1]

In 1916–17, Dr. Th. G. Halle, at that time assistant to Professor A. G. Nathorst but later the successor of this eminent phyto-palæontologist as keeper of the Department of Fossil Plants in the Swedish State Museum, traveled extensively in China for the purpose of collecting material from the fossil floras.

After Dr. Halle's return to Sweden we have continued to collect material for him and his associates who are now working on a number of monographs to be published in the Palæontologia Sinica.

By far the most interesting among the plant-bearing beds of China is the Permo-Carboniferous coal series. A facies of this series, well known through Schenk's researches, is the Kaiping flora of northeast Chihli, a flora of normal Palæozoic type.

Richthofen found another singular Palæozoic association of plants in Honan, the *Gigantopteris* flora, which has later been made known from Yunnan, Fukien, Manchuria and Korea by the work of French geologists, by Dr. Ting's collections, and by an important paper on this flora by Yabe.[2]

A most interesting development in our knowledge of this remarkable flora began in 1919 when one of my private Chinese collectors found in central Shansi a deposit containing numerous unusually well-preserved species belonging to the *Gigantopteris* flora.

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[1] A description of these collections prepared by Dr. Halle will soon appear in Dr. Ting's work on his research in Yunnan.

[2] Yabe. 'Geological and Geographical Distribution of *Gigantopteris*.' Science Reports of the Tohoku Imperial University. Second series, IV, No. 2.

A young Swedish geologist, Mr. E. Norin, invited to China by Professor E. T. Nyström of Taiyuanfu University, undertook at my suggestion a detailed survey of the whole younger Palæozoic series of Central Shansi. His research has given results beyond our expectations by revealing a succession of different floras in the lower part of the series interbedded with marine horizons abounding in fosssils, of which preliminary determinations have been made by Dr. Grabau. A paper by Mr. Norin including lists of these species will appear in an early number of the Bulletin of the Survey and will explain the sequence of these floras and their relations to marine horizons.

Similar stratigraphic researches coupled with extensive collecting of plants and marine fossils have been undertaken by C. C. Wang of The Geological Survey in northern Shansi and by Professor J. S. Li of Peking National University in northern Honan.

Large collections of the *Gigantopteris* flora as well as of marine fossils, in the provinces of Fukien and Kiangsi, have been made by Mr. J. T. Wang of the Geological Survey together with my collector, Chen.

The Mesozoic floras of different provinces have also yielded a considerable harvest, among which the extensive material of the Jurassic of northern China stands next in importance.

In northern China, Fengtien, Chihli, and Shansi, plant-bearing beds of early Tertiary age have been found, these being associated with and for the most part interbedded between basalt beds. The flora of Fushun in Fengtien is the most important of these deposits, and it has been described in the Palæontologia Sinica by Dr. Florin of the Stockholm Museum.[1] The principal species of this flora are enumerated in the table on the Cenozoic deposits which is appended to this paper.

Fossil Vertebrates

Apart from the early notes by Owen, Lydekker, and Gaudry, the fossil mammals of China have been described by Koken (Richthofen's collections) and above all by Schlosser in his work 'Die fossilen Säugethiere Chinas.'[2]

Schlosser's material was bought in Chinese medicine shops and was consequently very fragmentary, consisting mostly of isolated teeth only. Moreover, the localities were mostly unknown or in other cases were wrongly recorded. When these deficiencies, unavoidable at that time, are taken into consideration, it must be admitted that Schlosser's work

[1]Florin. 'Zur alttertiären Flora der Südlichen Mandschurei.' Palæontologia Sinica, Ser. A, I, Fasc. 1.

[2]Abhandl. des K. bayer. Akademie des Wiss., II Cl., XXII Bd., München, 1903.

is a masterly treatise on the subject. The immense progress which was made by him is shown by the fact that he recorded not less than 85 species of fossil mammals.

My own researches on the mammal deposits of China were begun in 1917 in coöperation with the Geological Survey and have been almost exclusively confined to northern China and a small area in Inner Mongolia.

As a result of this work we have not only brought together extensive collections of many mammal species, represented often by complete skulls and occasionally even by more or less complete skeletons, but we have also discovered a considerable number of vertebrate deposits representing a sequence of Cenozoic strata hitherto largely unknown in China.

The successive Tertiary and Pleistocene zones thus far recognized are shown in the accompanying table, and it will suffice to add some notes referring to the occurrence and distribution of these deposits.

Fossiliferous Eocene beds were first found by me in 1916 at Yüan Chü city, southeast Shansi, close to the Yellow River. I at first mistook these beds for deposits of early Pleistocene age, but the identification by Dr. N. Hj. Odhner, of the Stockholm Museum, of the mollusks found in them with species characteristic of the Eocene of France and western Germany proved the true age of these beds. Consequently, to Dr. Odhner is due the credit of having first recognized the occurrence of Eocene in China.[1]

The Eocene series of Yüan Chü Hsien consists of conglomerates, red and variegated clays, white sand, and thin beds of greenish-blue marly limestone, and attains a thickness of more than 1,000 meters. It forms a sunken area ("Graven") bounded by hills of Proterozoic and Palæozoic rocks.

Most of the mammal remains noted in the stratigraphic table were found by me on a second visit in May 1921 and were identified by Mr. Granger. The additional highly interesting discovery of the rhinocerid *Amynodon* was made in December 1921 by my palæontological collaborator, Dr. Otto Zdansky, Associate Palæontologist of the Geological Survey, who also has identified the reptiles from the Eocene beds as well as many mammals from the younger deposits. I take this opportunity to express to Mr. Granger and to Dr. Zdansky my sincere thanks for their most welcome help.

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[1] N. Hj. Odhner. 'Lacustrine Mollusca from Eocene deposits in China.' Bulletin of the Geological Survey of China, No. 4.

In the preceding section of this paper, while speaking of the fossil plants, I have already mentioned plant-bearing beds connected with basalts which have been referred by Florin to the Oligocene. No vertebrate remains have thus far been discovered in this section of the Cenozoic sequence.

The *Hipparion* clays of northern China are the richest deposits of fossil mammals so far known in this country. Until recently the mode of occurrence of the *Hipparion* fauna has been enveloped in a veil of mystery. From the study of his "medicine-bones" Schlosser recognized a very rich association of species accompanying *Hipparion*, but the geological records, such as Richthofen's and Bailey Willis' monographic works, give no information as to the deposits containing this abundant and remarkable fauna. On the other hand, the source of the "medicine bones" could be traced only with much difficulty as they had passed through so many hands that the origin had been nearly lost sight of.

However, we succeeded in locating some typical *Hipparion* localities in Honan and Shansi, and through this it became evident that the earlier explorers, such as Richthofen and Bailey Willis, had not distinguished the Pliocene clays from the Pleistocene loess, but included nearly all kinds of Cenozoic deposits under the latter name. Loczy alone made a proper distinction between the Pliocene clays and the overlying loess.

Only a small part of the rich *Hipparion* fauna has thus far been identified and could be mentioned in the stratigraphic table. A large number, including some very remarkable types, will be described in due course in the Palæontologia Sinica.

In August 1921 a mammal deposit was discovered at Chou K'ou Tien, about 45 km. southwest of Peking, on the occasion of a joint excursion undertaken by Mr. Granger, Dr. Zdansky, and myself. This was a cave deposit in the Ordovician limestone, and was subsequently excavated by Dr. Zdansky, who has communicated the preliminary list of the fossils given in the table. An article describing this deposit, tentatively considered to be Upper Pliocene, has been prepared by Dr. Zdansky and will appear soon in the Bulletin of the Geological Survey.

In 1918 Dr. V. K. Ting, the Director of the Geological Survey, discovered near the San Men rapids in the Yellow River, on the Shansi-Honan border a series of stratified sands and gravels below the loess, which were characterized by the frequent occurrence of very large freshwater mussels which belong, according to determinations of Dr. Wm. H. Dall in Washington, to the genera *Quadrula* and *Cuneopsis*. Similar

deposits were found by myself in other localities along the Yellow River. They contain, besides the mussels, some few and fragmentary mammal bones, which have thus far not been identified.

No deposit of China is more famous, singular and apt to challenge the explanatory efforts of the geologist than the North China loess, the Huang T'u of the Chinese language. Many interpretations of this peculiar and widely distributed soil have been given by different scientists but none seems better to correspond to all its topographic, geological and physical properties than the wind-drift theory first advocated by Richthofen. Nevertheless, our recent fossil finds in the loess have brought into the discussion arguments of a very conflicting nature.

Fossils are always very rare and mostly isolated in the loess. One of the most common is the egg of a big ostrich, first described by Brandt from S. Russia under the name *Struthiolithus chersonensis*. This bird might very likely have been a steppe form and thus would fit in well with the eolian theory.

Another rather common fossil of the loess is an *Elephas* which has been identified by Dr. Zdansky as probably *E. namadicus*. If this identification is confirmed when the material is definitely worked out, it will be a remarkable fact, for we would hardly expect to find in a steppe, or rather a semi-desert deposit such as was postulated by Richthofen, an elephant species which was originally described from the ancient alluvium of the Narbada valley in India.

There are other discoveries in the loess pointing to much more aquatic conditions than would be allowed by the eolian theory, as for instance the presence of a beaver and of a turtle.

It must be specially emphasized that these discoveries all refer to the genuine unstratified loess. There are also more recent beds of redeposited loess, more or less abundantly interstratified with gravel and in its present condition representing more truly a fluviatile deposit. In such redeposited loess in northernmost Chihli there has been found a very large bighorn sheep (first identified by Mr. Roy Chapman Andrews) and a deer.

In Inner Mongolia we have carried on the collecting of fossil vertebrates only in a very small area, about 130 km. north of Kalgan. The most interesting find is a deposit of sand containing a microfrauna, *Lagomys*, *Talpa*, *Lepus*, *Dipus*, *Castor*, amphibians, fishes and very numerous fresh-water mollusks together with some bigger forms such as *Cervavus*, a rhinocerid and fragments of big bird eggshells suggesting *Struthiolithus*.

The deposit is of singular interest because of the strongly aquatic character of the fauna (*Castor*, frogs, fishes and several species of fresh-water shells) all of which indicate a climate widely different from that of the present day.

Early Man

Very little systematic work has thus far been carried on in China for the study of prehistoric man and consequently our knowledge of this field is very deficient.

In Schlosser's collection there was a tooth of an anthropoid mammal, possibly an early type of man, and the Japanese palæontologist Matsumoto has described from Honan a fossil human sacrum which, according to his opinion, shows a striking similarity to the sacrum of the *Homo neanderthalensis* of Western Europe.[1]

In our research we have never come across any undisputed proof of Palæolithic Man. Northernmost Chihli has furnished a big "laurel-leaf" shaped instrument of the type which, among European archæologists, is considered to be characteristic of the Solutrean stage. But it appears that the type has survived in the Neolithic period, and such an isolated find, at the very best, can be taken only as an encouragement for further research in the same area.

Even the Neolithic has thus far yielded no undisputed traces in China. We have recently found and excavated extensive deposits of a Neolithic type. They have never yielded any metal objects but numerous artifacts of stone, bone, deer antlers, pig tusks, etc., as well as potsherds in great abundance. In most respects it is a true Neolithic furniture, but the pottery looks too rich and varied to make such a great age probable and there are many vessels which seem to have been turned upon the potter's wheel. There are also fragments of a fine polychrome ware strongly suggesting the polychrome pottery collected by Pumpelly in his oldest culture, Anau I, in Russian Turkestan. When all these facts are taken into consideration I would prefer tentatively to place this culture in the transition period to the early metal ages.

Some of the ceramic forms show striking affinity to pottery and bronzes of early Chinese history, especially the Chou Dynasty. There is consequently little doubt that we are dealing here with an early Chinese culture.

Detailed descriptions of these sites and their furniture will appear soon in the Palæontologia Sinica.

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[1]Matsumoto, 1915, 'On some fossil Mammals from Honan, China.' Reports of the Tohoku Imperial University, Geology, III, No. 1.

Pleistocene	*Upper*	Redeposited Loess and gravel in N. Chihli with *Ovis, Cervus, Bos.*	
	Middle	Primary Loess (Largely eolian) with *Struthiolithus chersonensis* and *Elephas cfr. namadicus.*	
	Lower	San-Men Series: Fluviatile gravel, sand and clay in the Yellow River valley, with fragmentary mammal remains and freshwater bivalves: *Quadrula cfr. spurius, Qu. cfr. affinis, Cuneopsis cfr. capitatus.*	
Pliocene	*Upper*	Cave-deposit of Chou-K'ou-Tien, Chihli: *Ursus, Hyæna, Machairodus,* Rhinocerid, *Equus, Sus,* Cervid, Bovine and other *Artiodactyla, Talpa,* Rodents (2 sp.), Bird.	
Miocene	*Lower Pliocene or Upper Miocene*	Hipparion Clays of Shansi, Honan, Shensi and Kansu; red and variegated clays with lime carbonate concretions and gravel beds: *Cynoephalus?, Machairodus, Ictitherium?, Hyæna, Mastodon, Elephas, Aceratherium, Hipparion richthofeni, Sus* (2 sp.), *Tragocerus, Cervavus, Giraffine, Struthio.*	
Oligocene	*Fushun Series*	Coal Bearing Series of Fu-Shun and Shih-Men-Chai in Fengtien province: tuffaceous sandstone, conglomerate and shale (740 m.) with thick coal seams: *Osmunda lignitum. Sequoia langsdorfi, Glyptostrobus europaeus, Populus glandulifera, Alnus kefersteini, Dryophyllum dewalqui, Fugus feroniae, Zelkova ungert,* etc. Soft Shale of Han-Jo-Pa in southern-most Chahar with *Pinus, Comptonia anderssoni, Carpinus?, Phyllites.* Sandstone, Shale, Clay and Coal at Shang-Yang-Kou, Fan-Chih-Hsien, Shansi, with undetermined plant-fossils.	The plantbearing deposits of Fengtien, Chahar and Shansi, here described, all occur in connection with basalt beds and may be approximately contemporaneous.
Eocene	*Yüan-Chu Series*	Conglomerates, Red and Variegated Clays, White Sand and Greenish Blue Marly Limestones with *Chara,* Ostracoda, *Planorbis pseudammonius, Pl. sparnacensis, Pl. chertieri, Physa cfr. lamberti, Euchilus deschensianum, Ceratodes sinensis, Eupera sinensis.* Also numerous but fragmentary vertebrate remains; *Teleostei, Chelonia (Trionyx), Crocodilia* and some few Mammals (*Amynodon,* Rodent, Lemuroid or Insectivore).	

Provisional List of the Hipparion Fauna (Lower Pliocene) of North China

Prepared by Dr. O. Zdansky

Anthropoidea
- *Cynocephalus*, 2 species

Perissodactyla
- *Hipparion richthofeni* Schl.
- *Teleoceras*, 4 species
- *Aceratherium*
- *Sinotherium lagrelii* Ringström[1]
- *Anchitherium*

Artiodactyla
- Cervidæ of different size
- Many antelopes
- *Chilinotherium tingii* Wiman[2]
- *Sus*, 2 species

Carnivora
- *Hyæna*
- Viverridæ, several species
- Felidæ
- *Machairodus*
- ?*Arctocyon* or *Hyænarctos*
- Mustelidæ, 2 species

Proboscidea
- *Mastodon*
- *Stegodon*
- *Elephas*

Rodentia
- Castorid
- Rodent of squirrel size

Aves
- Struthionid

Reptilian
- Emydid
- Testudinid

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[1] A new type of Rhinoterotidæ. For type description, see: T. J. Ringström, '*Sinotherium lagrelii*, a new fossil rhinocerotid from Shansi, China.' Bull. Geol. Survey, No. 5.

[2] A new member of the Giraffidæ.

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